FISHERY MANAGEMENT INVESTIGATIONS

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KOKANEE EVALUATIONS

ABSTRACT

We estimated age-specific abundance, density, and population characteristics (i.e., growth, recruitment stability, and total annual mortality) of kokanee *Oncorhynchus nerka* in Lake Coeur d'Alene and Spirit Lake to monitor trends in the fishery. A modified midwater trawl was used to sample kokanee during July 26–28, 2014. We estimated a total abundance of approximately 8,100,000 and 1,600,000 kokanee in Coeur d'Alene Lake and Spirit Lake, respectively. Mean total length of adult kokanee in Lake Coeur d'Alene was 238 mm, which is below the desired range used to index adult size structure. Despite the low average size, the Lake Coeur d'Alene kokanee population had strong numbers of adult fish during 2014 and has shown stable recruitment over the past three years suggesting that the fishery should remain consistent into the foreseeable future. We documented the highest adult kokanee densities on record for Spirit Lake, likely the result of the strong 2011 year-class. Size structure of kokanee in Spirit Lake was poor (mean age-3 TL = 194 mm) and body condition was fair (mean W_r = 78.45). We hypothesize that this is likely a response to high densities. Recruitment has been very stable suggesting that the trends in growth, and subsequently size structure, may persist during the next few years. Total annual mortality of kokanee in Spirit Lake was lower than that of the Lake Coeur d'Alene population and reflects the lack of predators and likely lower angler harvest in Spirit Lake. We recommend continued monitoring of the Lake Coeur d'Alene kokanee population to assess trends in age-specific abundance and growth. We also recommend proposing a bag limit change from 15 to 25 fish per day in Spirit Lake to encourage harvest of the abundant kokanee to reduce density and improve the average size. In addition, follow-up monitoring in Spirit Lake over the next several years will be necessary to document population-level responses to the regulation change, if adopted.

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INTRODUCTION

Kokanee *Oncorhynchus nerka* are a popular sport fish across much of the western U.S. because of their high catchability and table value. Kokanee angling is especially popular among local anglers because it is family-oriented, consistently entertaining, and requires simple gear. Kokanee comprise much of the fishing effort in northern Idaho lakes, making them an important focus of management efforts. The Idaho Department of Fish and Game's (IDFG) current policy is to manage for adult kokanee abundances that support high annual harvest yields and provide forage for predators. Current and continued evaluations of kokanee populations in Lake Coeur d'Alene and Spirit Lake will provide information necessary to manage these fisheries.

Kokanee were introduced to Lake Coeur d'Alene in 1937 by the IDFG to establish a harvest-oriented fishery (Hassemer and Rieman 1981; Maiolie et al. 2013). Initial introductions were made from a late-spawning shoreline stock from Lake Pend Oreille (Lake Whatcom stock). During the early 1970s, attempts were made to introduce kokanee from an early-spawning (Meadow Creek) stock in Lake Coeur d'Alene; however, early-spawning kokanee failed to establish a wild population and had dwindled by 1981 (Goodnight and Mauser 1980; Mauser and Horner 1982). Despite unsuccessful attempts to establish early-spawners, the kokanee fishery peaked in the mid-1970s and the wild component was producing annual yields between 250,000–578,000 fish during that time (Goodnight and Mauser 1980; Rieman and LaBolle 1980). By the early 1980s, fishery managers had documented density-dependent effects on adult kokanee size, which prompted an increase in the daily bag limit from 25 to 50 fish per day and the introduction of Chinook Salmon *O. tshawytscha* as a biomanipulation tool to reduce kokanee abundance (Mauser and Horner 1982). Chinook Salmon naturalized in the system and are now an important component of the Lake Coeur d'Alene fishery. In recent history, the kokanee population has not been highly influenced by the abundance of predators, but rather by environmental conditions, particularly spring flooding.

Kokanee populations are greatly influenced by environmental conditions, and stochastic events can alter dynamic rate functions which can often have long-lasting effects on a population (Hassemer 1984). Poor recruitment commonly results from adverse environmental conditions and can be problematic from a fisheries management standpoint because kokanee are semelparous, and thus it may take several generations for recruitment to return to form. This dynamic was shown in Lake Coeur d'Alene where weak year-classes have resulted from high spring runoff events (i.e., 1996 flooding). The weak 1996 year-class resulted in low recruitment during subsequent years which translated into low abundance of harvestable age-3 and age-4 kokanee during 1998–2003. Lake Coeur d'Alene also has several piscivorous predators which prey upon kokanee at various life stages. As such, poor environmental conditions coupled with high predator abundance can have cumulative negative effects on kokanee dynamic rate functions, and thus abundance. The IDFG maintains long-term data on the kokanee population dynamics and abundance in Lake Coeur d'Alene to continually evaluate population-level changes resulting from environmental factors and fishery management. In addition, annual assessment of the kokanee population provides IDFG and anglers with valuable information on the status of the fishery.

Late-spawning kokanee were also transplanted from Lake Pend Orielle to Spirit Lake in the late 1930s (Maiolie and Fredericks 2012), and this stock has traditionally supported the wild component of the fishery. According to Rieman and Meyers (1990), Spirit Lake historically produced some of the highest relative annual yields of kokanee throughout the western U.S. and Canada. Attempts have been made to establish early-spawning kokanee to diversify the fishery, the last being in 2008 (Maiolie et al. 2013). However, it has been thought that beaver dams and limited spawning habitat precluded them from naturalizing and significantly contributing to the fishery. Recent population evaluations have shown that abundance of wild adults has been sufficiently high, so hatchery stocking was discontinued in 2010. In fact, recent kokanee assessments have shown fish are exhibiting slow growth relative to other systems, likely due to density-dependent effects.

OBJECTIVES

1. Maintain long-term monitoring data to provide information related to kokanee management in Lake Coeur d'Alene.

2. Estimate population characteristics of kokanee populations in Lake Coeur d'Alene and Spirit Lake.

3. Evaluate potential management actions to improve kokanee angling in Lake Coeur d'Alene and Spirit Lake.

STUDY AREA

Lake Coeur d'Alene

Lake Coeur d'Alene is a mesotrophic natural lake located in the Panhandle of northern Idaho (Figure 1). Lake Coeur d'Alene lies within Kootenai and Benewah Counties and it is the second largest natural lake in Idaho with a surface area of 12,742 ha, mean depth of 24 m, and maximum depth of 61 m (Rich 1992). The Coeur d'Alene and St. Joe rivers are the major tributaries to Lake Coeur d'Alene; however, many smaller tributaries contribute flow as well. The outlet to Lake Coeur d'Alene is the Spokane River, a major tributary to the Columbia River. Water resource development in the lake includes Post Falls Dam which was constructed on the Spokane River in 1906, and raised the water level approximately 2.5 m. In addition to creating more littoral habitat and shallow-water areas, the increased water level created more pelagic habitat for open-water salmonids (e.g., kokanee, Chinook Salmon).

The fishery in Lake Coeur d'Alene can be broadly characterized as belonging to one of 3 components—kokanee, Chinook Salmon, or warmwater species; all of which are popular among anglers. The fish assemblage has become increasingly complex over time, particularly during the past 30 years. Increased fish assemblage complexity has undoubtedly resulted in increased biological interactions, but also diversified angler opportunity. Because of its close proximity to several major cities (i.e., Coeur d'Alene, Spokane, Missoula), Lake Coeur d'Alene generates high angling effort, contributing considerably to state and local economies. According to a 2011 survey of the economic impact of angling in Idaho, Lake Coeur d'Alene generated ~ $11 million and 84,000 angler trips, making this lake third in total number of angler trips behind CJ Strike Reservoir and the Henrys Fork (IDFG, unpublished data). This impact was second in the state to the famed Henrys Fork River in eastern Idaho.

Spirit Lake

Spirit Lake is located in Kootenai County near the town of Spirit Lake, Idaho (Figure 2). The lake has a surface area of 596 ha, a mean depth of 11.4 m, and a maximum depth of 30.0 m. Brickel Creek is the largest surface water tributary to the lake and drains a forested interstate watershed extending into eastern Washington. Brickel Creek originates on the eastern slope of Mount Spokane at approximately 744.0 m in elevation and flows in an easterly direction before forming Spirit Lake. Spirit Lake discharges into Spirit Creek, an intermittent outlet located at the northeastern end of the lake; Spirit Creek flows into the Rathdrum Prairie where flow typically becomes subterraneous and contributes to the Rathdrum Aquifer. Spirit Lake is considered mesotrophic having the following water quality concentrations: chlorophyll *a* = 5.3 µg/L (Soltero and Hall 1984), total phosphorus = 18 µg/L, and Secchi depth = 3.9 m (Rieman and Meyers 1991).

The fishery in Spirit Lake has two main components: kokanee and warmwater species. Size structure of kokanee in Spirit Lake has been poor in recent years and anglers seem to have lost interest in the fishery. However, when conditions allow, the lake supports a popular ice fishery targeting kokanee and yellow perch.

METHODS

<u>Fish sampling and processing</u>

Population monitoring

During 2014, kokanee were sampled from Lake Coeur d'Alene and Spirit Lake in northern Idaho on July 26–27 and July 28, respectively. Kokanee were sampled using a modified midwater trawl (hereafter referred to as the trawl) towed by an 8.0-m boat at a speed of 1.55 m/s. Due to constraints, we used the "southern Idaho" trawl boat which is a smaller version of the boat routinely used to sample northern Idaho lakes. The midwater trawl is a gear that has been successfully employed in large lentic systems for sampling kokanee (Rieman 1992).The trawl consisted of a fixed frame (3.2 m × 2.0 m) and a single-chamber mesh net (6.0-mm delta-style No. 7 multifilament nylon twine, knotless mesh). Further, the trawl assembly consists of two winch-bound cable towlines which are each passed through a single pulley block. The pulley blocks are vertically-attached to a 2.4-m tall frame mounted to the stern of the boat allowing the trawl to be easily deployed and retrieved during sampling. Further information on the trawl can be found in Bowler et al. (1974), Rieman (1992), and Maiolie et al. (2004).

Trawling was conducted at 21 and 5 predetermined transect throughout Lake Coeur d'Alene and Spirit Lake, respectively (Figure 1, Figure 2). Transects were originally assigned using a systematic sampling design and have remained the same to standardize abundance estimates (Maiolie and Fredericks 2014). During fish sampling, the bottom and top of the kokanee layer was identified by the boat operator and the trawl was towed for 3 minutes in a stepwise pattern with 2.4-m increments to capture the entire layer at each transect (Rieman 1992). Upon retrieval of the trawl, kokanee were measured for total length (TL; mm), weighed (g), and saggital otoliths were collected from 10 individuals per 1-cm length group if available. Otoliths were removed following the procedure outlined by Schniedervin and Hubert (1986) and horizontally mounted in epoxy using PELCO flat embedding molds (Ted Pella, Inc., Redding, California, USA). Otoliths were cross-sectioned transversely with sections bracketing the nucleus to capture early annuli. Resulting cross-sections were polished with 1,000-grit sandpaper and viewed using a dissecting microscope to estimate age.

Lake Coeur d'Alene spawner assessment

Kokanee spawner length and age structure was estimated to evaluate growth objectives. Spawners were sampled on December 1, 2014 using an experimental gill net (46.0 m × 1.8 m with panels of 25, 32, 38, 44, and 50-mm bar-measure mesh). The net was set for ~20 minutes near Higgens Point in Lake Coeur d'Alene. Sampled fishes were sexed and measured for TL (mm). In addition, otoliths were removed via the "up-through-the-gills" method (Schneidervin and

Hubert 1986) from five individuals per 1-cm length group immediately after sampling. Otoliths were viewed whole by a single reader using a dissecting microscope with reflected light.

Data Analysis

Body condition of kokanee was evaluated using relative weight (W_r; Neumann et al. 2012). Relative weight values were calculated as

$$W_r = (W / W_s) \times 100,$$

where W is the weight of an individual and W_s is the standard weight predicted by a species-specific length-weight regression (Neumann et al. 2012). A W_r value of 100 indicates average body condition, W_r values below 100 indicate poor body condition, and W_r values above 100 indicate good body condition.

Age structure of both populations and Lake Coeur d'Alene spawners was estimated using an age-length key (Isermann and Knight 2005; Quist et al. 2012). Total annual mortality (*A*) was estimated using a weighted catch curve (Miranda and Bettoli 2007). Only age-1+ kokanee appeared to be fully recruited to the sampling gear, so *A* was estimated for age-1 and older fish. Recruitment was described using several techniques. Recruitment was first indexed using the residual technique described by Maceina (1997) where positive residuals represent strong year-classes and negative residuals represent weak-year classes. The recruitment coefficient of determination (RCD; Isermann et al. 2002) was also used to explain stability in recruitment. The RCD is the coefficient of determination (r^2) value that results from a catch-curve regression with r^2 values closer to 1.00 indicating more stable recruitment. Indices of recruitment are often useful for comparing among water bodies and provide a general idea of recruitment stability over multiple years.

Length frequency information from trawling and spawning index netting was summarized to provide insight on size structure and length-at-age. Growth was summarized using mean length at age data.

Total population abundance estimates have traditionally been used to index the kokanee populations in both Spirit and Coeur d'Alene Lake. Therefore, we calculated total age-specific abundance (*N*) which could be compared to previous years' sampling.

RESULTS

Lake Coeur d'Alene

Population monitoring

We sampled a total of 1,208 kokanee by trawling in Lake Coeur d'Alene during July 26–27, 2014. We estimated a total abundance of 8,140,461 (90% CI = 5,939,459 – 10,341,459) kokanee and density of 861.16 kokanee/ha. Age-specific abundance was estimated in order to make comparisons with previous years and to provide insight on recruitment of adults to the fishery. We estimated abundances of 2.8 million age-0, 2.1 million age-1, 2.7 million age-2, and 319,000 age-3/4 kokanee based on trawling (Table 1). The highest kokanee fry densities were observed in the northern portion of the lake (Section 1; Figure 1), particularly near Wolf Lodge Bay. We observed much lower abundance of fry in sections 2 and 3. The highest adult abundance was observed in sections 1 and 2.

Kokanee sampled by trawling varied in length from 22–241 mm TL (Figure 3) and varied in age from 0–3 years old (Figure 4). Estimates of mean length-at-age varied slightly and represented very concise and predictable growth rates (Figure 5). Total annual mortality was high (A = 70.45) and recruitment has been very stable over the past 3 years (RCD = 0.99; Figure 6). Kokanee were in fair body condition (W_r = 77.44) and W_r did not tend to change as a function of age (Figure 7).

Spawner assessment

Spawning kokanee varied in length from 211–281 mm TL and varied in age from 3–4 years old. Of the adults sampled, 71% were age-3 and 29% were age-4. Similar to past years, female kokanee represented a smaller proportion of the sample (Figure 8). Mean TL was 238.60 mm (SD = 14.57) and 233.05 mm (SD = 11.77) for male and female kokanee, respectively. Overall mean TL was 238.19 mm (SD = 14.44). Mean TL of kokanee spawners in 2014 was lower compared to the past 17 years' estimates and was below the adult length objective (Figure 9).

Spirit Lake

Population monitoring

We sampled a total of 910 kokanee by trawling in Spirit Lake during July 28, 2014. We estimated a total abundance of 1,650,245 (90% CI = 817,764–2,482,726) kokanee. We estimated abundances of 44,295 age-0, 720,648 age-1, 653,945 age-2, and 231,356 age-3/4 kokanee based on trawling (Table 2). We estimated a total density of around 2,825 kokanee/ha and a density of 396 age-3 kokanee/ha (Table 2). Very few fry were sampled, and there did not appear to be any pattern in fry abundance around the lake. In addition, adults were well distributed around the lake and high abundances were observed at all transects.

Kokanee sampled during trawling varied in length from 32–216 mm TL (Figure 10) and varied in age from 0–3 years old (Figure 11). Estimates of mean length-at-age had little variability and represented very concise and predictable growth rates (Figure 5). Total annual mortality was 50.0% and recruitment has been relatively stable over the past 3 years (RCD = 0.86; Figure 12). Kokanee were in fair body condition (W_r = 78.45) and body condition did not tend to change as a function of age (Figure 13).

DISCUSSION

Lake Coeur d'Alene

The kokanee population in Lake Coeur d'Alene has supported a productive harvest fishery over the past five years and angling was reportedly good again during 2014. The population has been negatively affected by adverse environmental conditions, namely spring flooding (Maiolie et al. 2013). However, stable conditions more recently have improved the population. Recruitment has been very stable over the past three years, and we expect good adult recruitment to the fishery into the near future. In addition, we expect the kokanee population to provide a consistent forage base for Chinook Salmon.

We documented the lowest mean spawner length in 2014 compared to the previous 17 years, falling below the desired length range (Figure 9). The desired range has been traditionally used to indicate whether adult kokanee are meeting size structure objectives of at least 10 inches in the fall fishery. Our mean length estimate in 2014 (TL= 238.19 mm) was only slightly below the minimum bound of the desired range and we believe that the majority of adult kokanee in the population are still of desirable size to anglers. However, future monitoring efforts should assess trends in adult length so that drastic changes in growth can be identified.

Spirit Lake

Spirit Lake has historically been one of Idaho's top kokanee fishing waters (Maiolie et al. 2013). The lake supports a summer troll fishery and winter ice fishery making it an important regional resource. The kokanee population has a long history of being highly variable in terms of recruitment and growth, and this has held true over the last 15 years (Maiolie et al. 2013). The fishery has tended to follow suit whereby angling effort tracks adult abundance and size structure. However, the fishery can be variable due to ice conditions as well. The variability in the fishery seems to have persisted in recent history. Spirit Lake does not have any pelagic predators like the other large north Idaho lakes (i.e., Lake Pend Orielle, Lake Coeur d'Alene), so its kokanee population serves as a baseline upon which other kokanee populations can be compared (Maiolie et al. 2013). The absence of predators, however, also allows kokanee in Spirit Lake to obtain very high densities. As a reslt, the kokanee population often exhibits strong density-dependent growth, depressing size structure and reducing angler interest.

Based on sampling in 2014, kokanee in Spirit Lake have reached the highest adult (i.e., age-3) densities since sampling began in 1981. Although total abundance was similar to the most recent (2011) survey, age-3 abundance in 2014 was around threefold the observed abundance in 2011. Maiolie et al. (2013) documented a very strong year-class of age-0 kokanee during sampling in 2011 which comprised the adult population in 2014. The 2011 year-class is anomalous to typical Spirit Lake kokanee recruitment, and it appears to have decreased growth rates. Very few age-3 kokanee surpassed 200 mm TL and mean length of age-3 fish was about 194 mm. The relatively small size of adults has probably reduced interest from anglers. Follow-up sampling will be necessary in the future to document whether high adult abundances persist and to assess if rule changes have an effect on the quality of the fishery.

MANAGEMENT RECOMMENDATIONS

1. Continue annual kokanee population monitoring on Lake Coeur d'Alene.
2. Increase daily bag limit from 15 to 25 fish in Spirit Lake.
3. Perform follow-up sampling on Spirit Lake during 2015–2017 to evaluate regulation change.

Table 1. Estimated abundance of kokanee made by midwater trawl in Lake Coeur d'Alene, Idaho, from 1979–2014.

	Age class				
Year	Age-0	Age-1	Age-2	Age-3/4	Total
2014	2,877,209	2,153,877	2,790,295	319,080	8,140,461
2013	1,349,000	3,663,000	1,319,000	373,000	6,704,000
2012	--	--	--	--	--
2011	3,049,000	1,186,000	1,503,000	767,000	6,505,000
2010	660,400	2,164,100	1,613,300	506,200	4,943,900
2009	731,600	1,611,800	2,087,400	333,600	4,764,400
2008	3,035,000	3,610,000	1,755,000	28,000	8,428,000
2007	3,603,000	2,367,000	136,000	34,000	6,140,000
2006	7,343,000	1,532,000	91,000	33,900	8,999,000
2005	--	--	--	--	--
2004	7,379,000	1,064,000	141,500	202,400	8,787,000
2003	3,300,000	971,000	501,400	182,300	4,955,000
2002	3,507,000	934,000	695,200	70,800	5,207,000
2001	7,098,700	929,900	193,100	25,300	8,247,000
2000	4,184,800	783,700	168,700	75,300	5,212,600
1999	4,091,500	973,700	269,800	55,100	5,390,100
1998	3,625,000	355,000	87,000	78,000	4,145,000
1997	3,001,100	342,500	97,000	242,300	3,682,000
1996	4,019,600	30,300	342,400	1,414,100	5,806,400
1995	2,000,000	620,000	2,900,000	2,850,000	8,370,000
1994	5,950,000	5,400,000	4,900,000	500,000	12,600,000
1993	5,570,000	5,230,000	1,420,000	480,000	12,700,000
1992	3,020,000	810,000	510,000	980,000	5,320,000
1991	4,860,000	540,000	1,820,000	1,280,000	8,500,000
1990	3,000,000	590,000	2,480,000	1,320,000	7,390,000
1989	3,040,000	750,000	3,950,000	940,000	8,680,000
1988	3,420,000	3,060,000	2,810,000	610,000	10,900,000
1987	6,880,000	2,380,000	2,920,000	890,000	13,070,000
1986	2,170,000	2,590,000	1,830,000	720,000	7,310,000
1985	4,130,000	860,000	1,860,000	2,530,000	9,370,000
1984	700,000	1,170,000	1,890,000	800,000	4,560,000
1983	1,510,000	1,910,000	2,250,000	810,000	6,480,000
1982	4,530,000	2,360,000	1,380,000	930,000	9,200,000
1981	2,430,000	1,750,000	1,710,000	1,060,000	6,940,000
1980	1,860,000	1,680,000	1,950,000	1,060,000	6,500,000
1979	1,500,000	2,290,000	1,790,000	450,000	6,040,000

Table 2. Estimated abundance of kokanee made by midwater trawl in Spirit Lake, Idaho, from 1981–2014.

Year	Age class				Total	Age-3/ha
	Age-0	Age-1	Age-2	Age-3		
2014	44,295	720,648	653,945	231,356	1,650,245	396
2013	--	--	--	--	--	--
2012	--	--	--	--	--	--
2011	1,092,000	185,700	382,300	65,500	1,725,400	112
2010	138,200	459,900	88,800	61,600	748,500	105
2009	260,700	182,600	75,900	30,000	549,200	51
2008	281,600	274,400	188,800	56,400	801,200	96
2007	439,919	210,122	41,460	20,409	711,910	35
2006	--	--	--	--	--	--
2005	508,000	202,000	185,000	94,000	989,100	161
2001–04	--	--	--	-	--	--
2000	800,000	73,000	6,800	7,800	901,900	13
1999	286,900	9,700	50,400	34,800	381,800	61
1998	28,100	62,400	86,900	27,800	205,200	49
1997	187,300	132,200	65,600	6,500	391,600	11
1996	--	--	--	--	--	--
1995	39,800	129,400	30,500	81,400	281,100	142
1994	11,800	76,300	81,700	19,600	189,400	34
1993	52,400	244,100	114,400	11,500	422,400	20
1992	--	--	--	--	--	--
1991	458,400	215,600	90,000	26,000	790,000	45
1990	110,000	285,800	84,100	62,000	541,800	108
1989	111,900	116,400	196,000	86,000	510,400	150
1988	63,800	207,700	78,500	148,800	498,800	260
1987	42,800	164,800	332,800	71,700	612,100	125
1986	15,400	138,000	116,800	35,400	305,600	62
1985	149,600	184,900	101,000	66,600	502,100	116
1984	3,300	16,400	148,800	96,500	264,900	168
1983	111,200	224,000	111,200	39,200	485,700	68
1982	526,000	209,000	57,700	48,000	840,700	84
1981	281,300	73,400	82,100	92,600	529,400	162

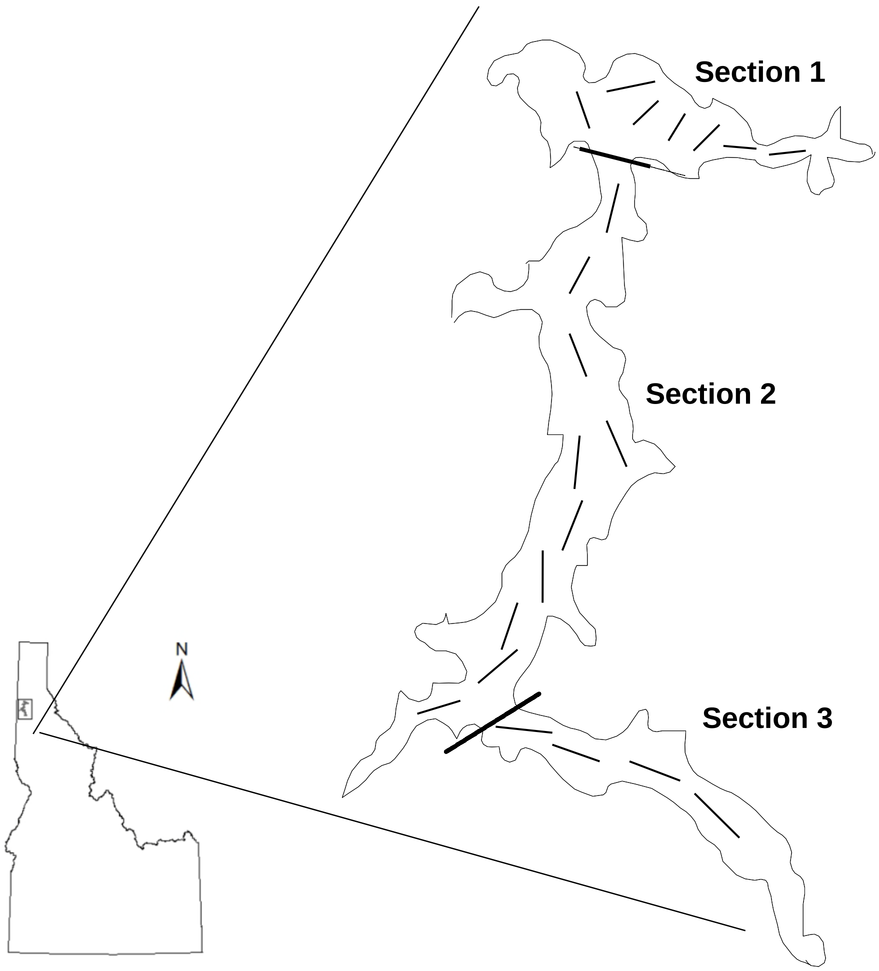

Figure 1. Approximate location of historical trawling transects used to estimate abundance of kokanee in Lake Coeur d'Alene.

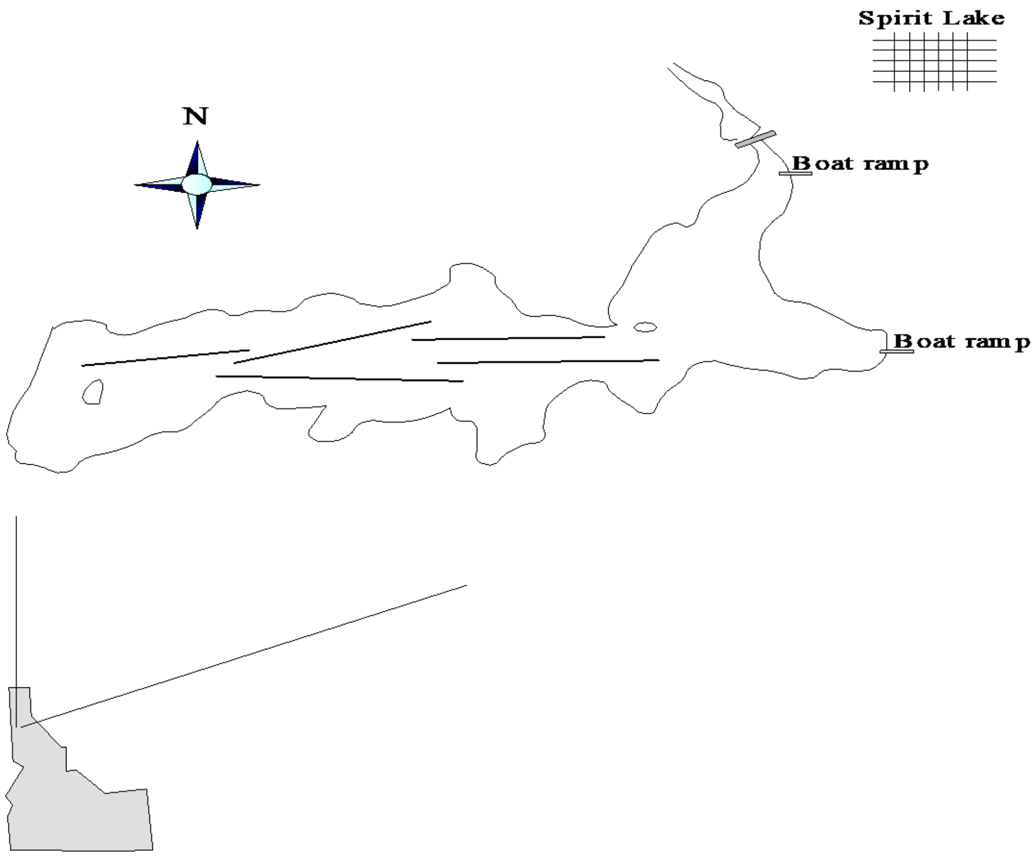

Figure 2. Approximate location of historical trawling transects used to estimate abundance of kokanee in Spirit Lake, Idaho.

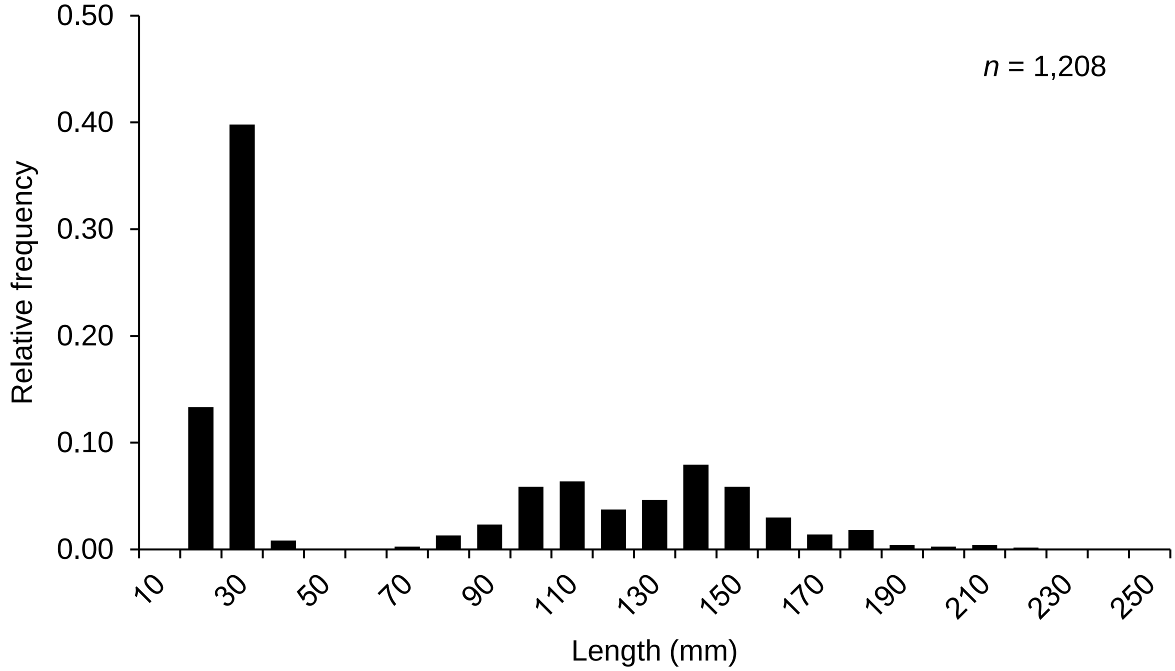

Figure 3. Length-frequency distribution for kokanee sampled using a modified-midwater trawl from Lake Coeur d'Alene, Idaho (July 26–27, 2014).

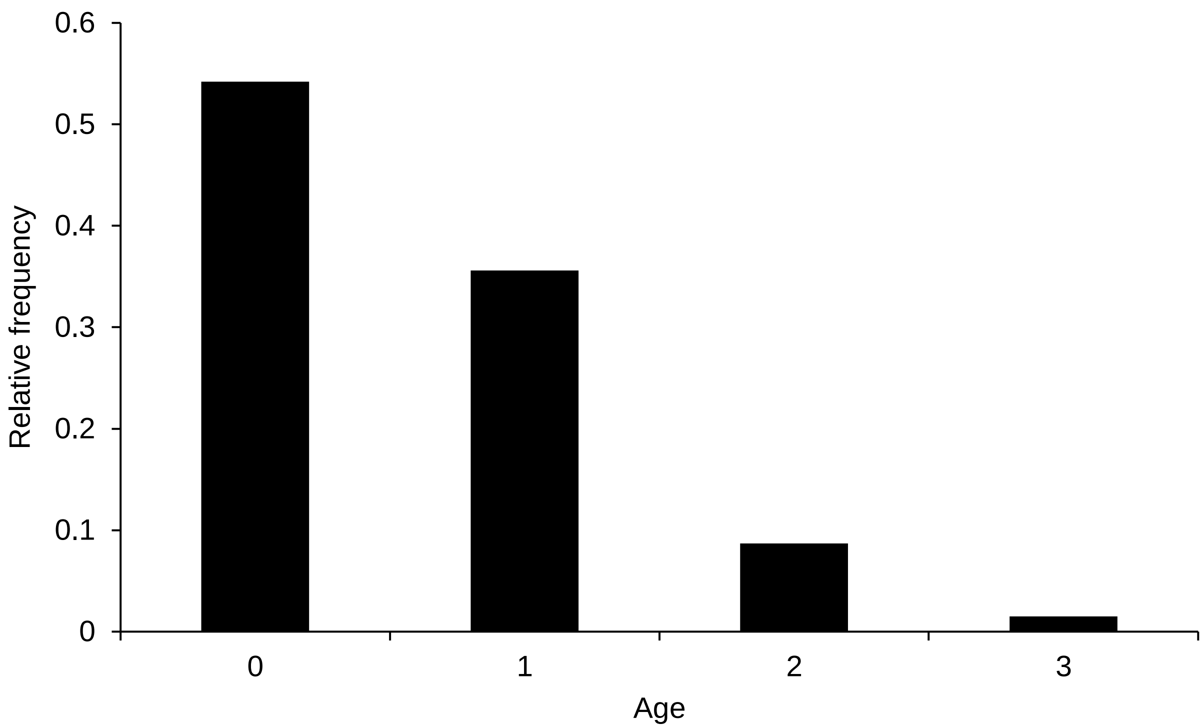

Figure 4. Age-frequency distribution for kokanee sampled using a modified-midwater trawl from Lake Coeur d'Alene, Idaho (July 26–27, 2014).

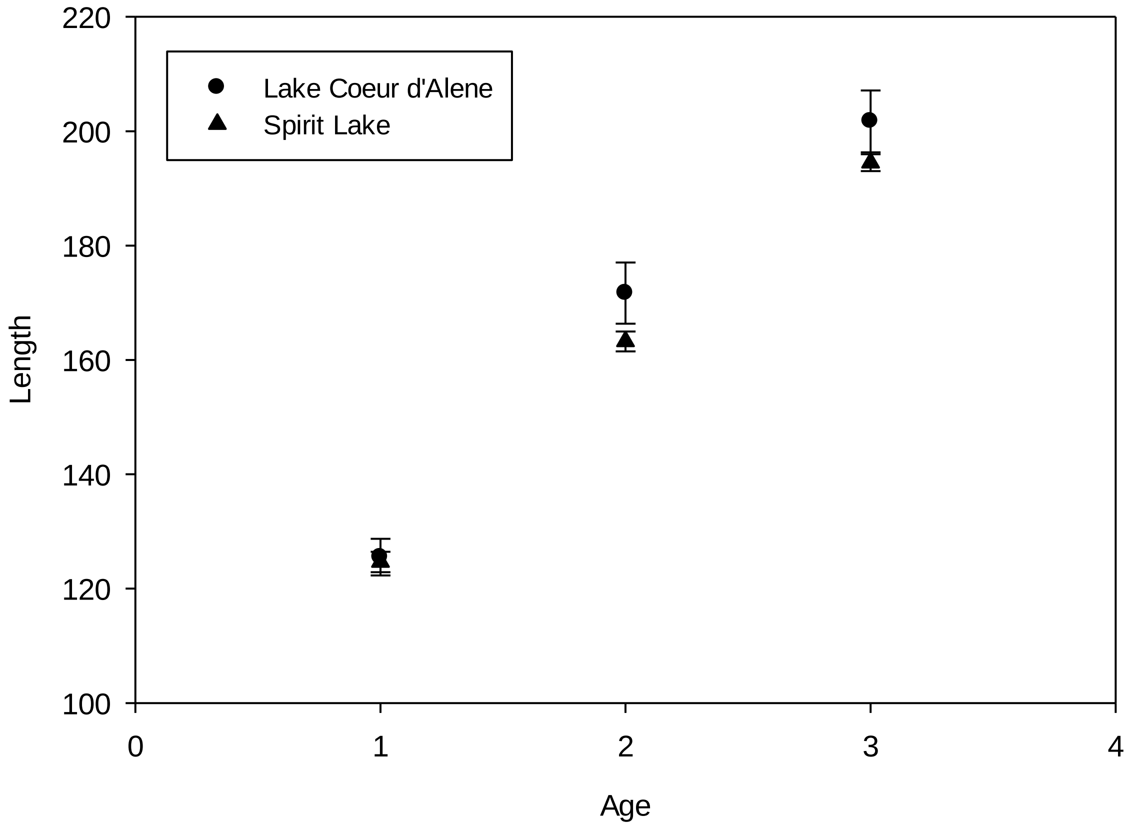

Figure 5. Mean length-at-age of kokanee sampled from Lake Coeur d'Alene and Spirit Lake, Idaho.

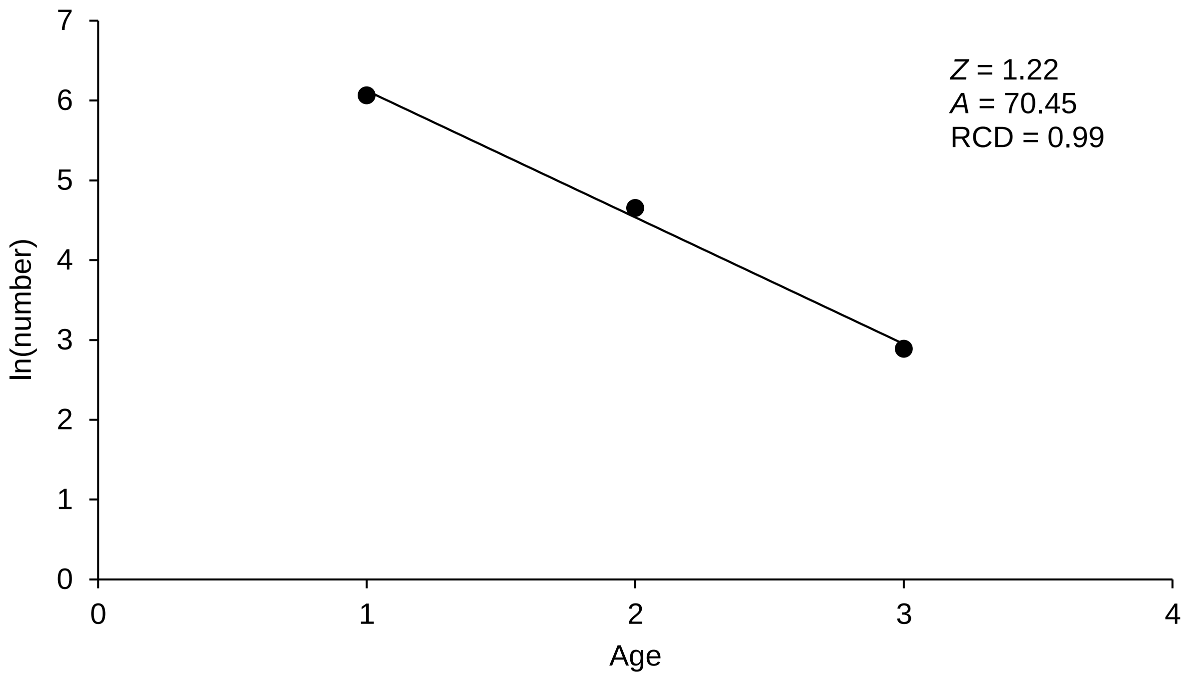

Figure 6. Catch curve regression estimating mortality and recruitment variability for kokanee sampled from Lake Coeur d'Alene, Idaho.

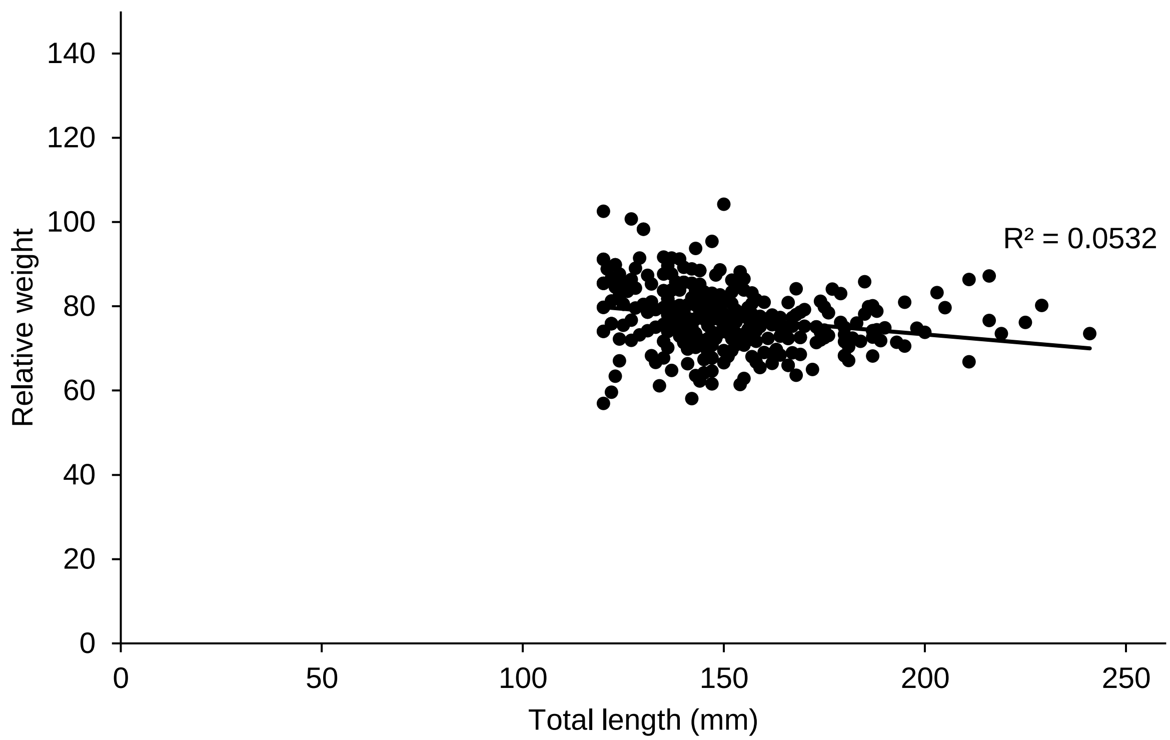

Figure 7. Relationship between total length and body condition of kokanee sampled from Lake Coeur d'Alene, Idaho.

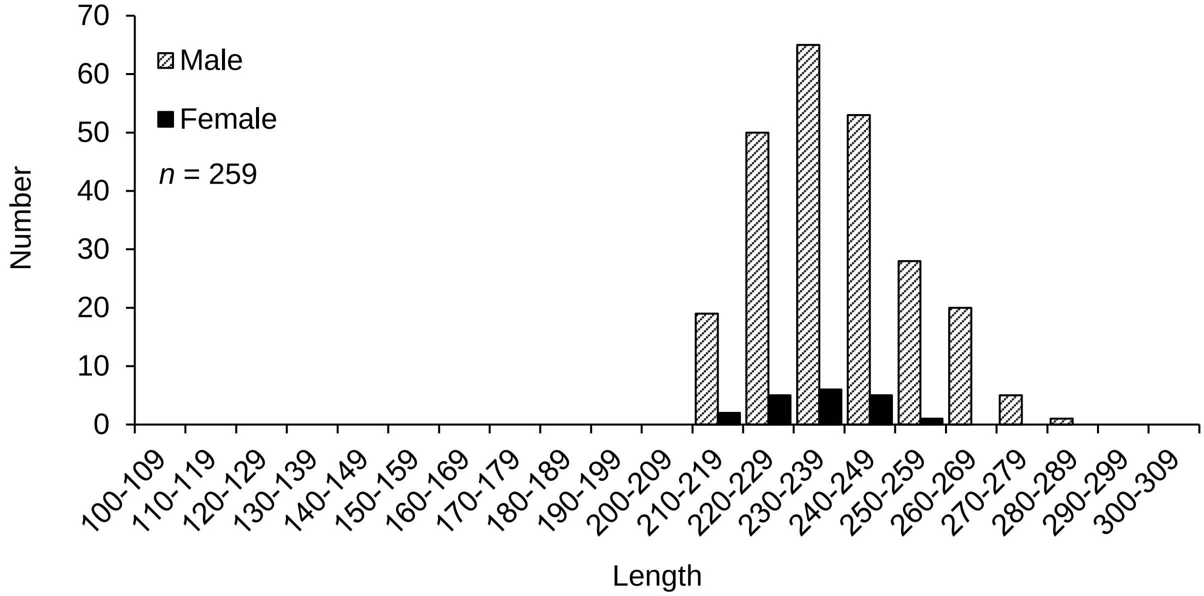

Figure 8. Length-frequency distribution for male and female kokanee sampled from Lake Coeur d'Alene, Idaho (December 1, 2014).

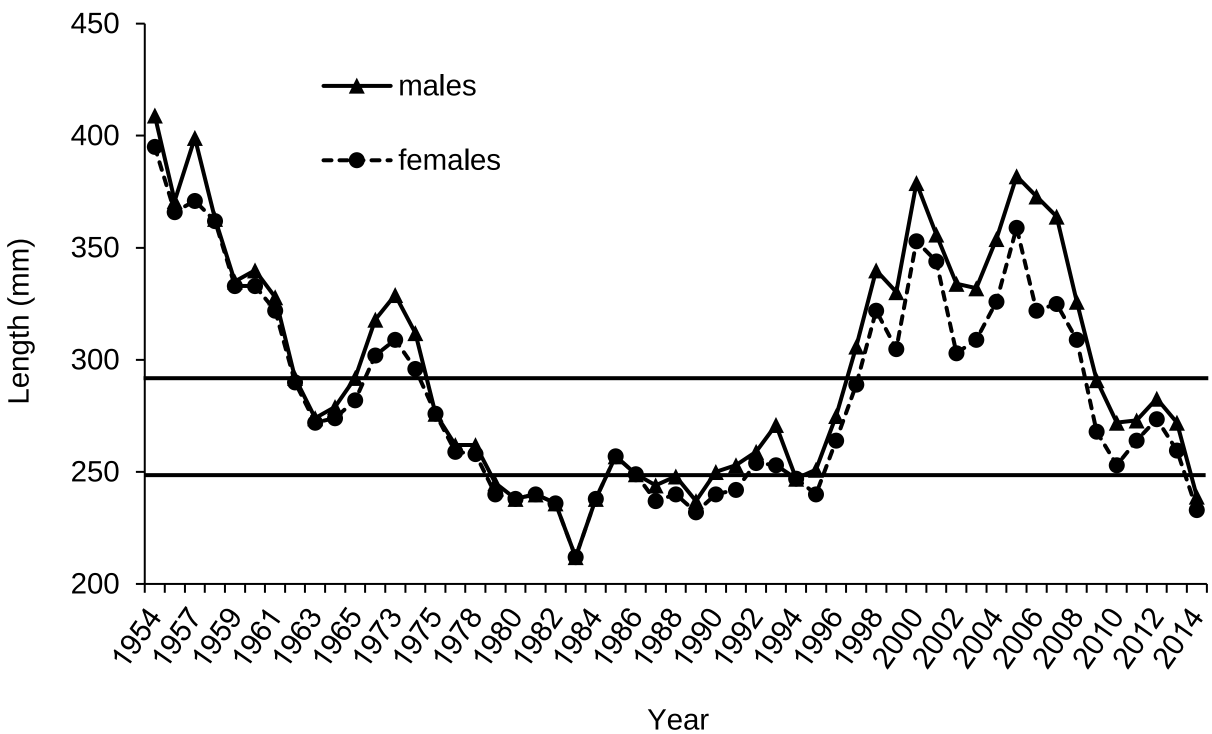

Figure 9. Mean total length of mature male and female kokanee sampled near Higgens Point in Lake Coeur d'Alene Idaho (December 1, 2014).Horizontal lines indicate the upper and lower limit of the adult length objective (250–280 mm).

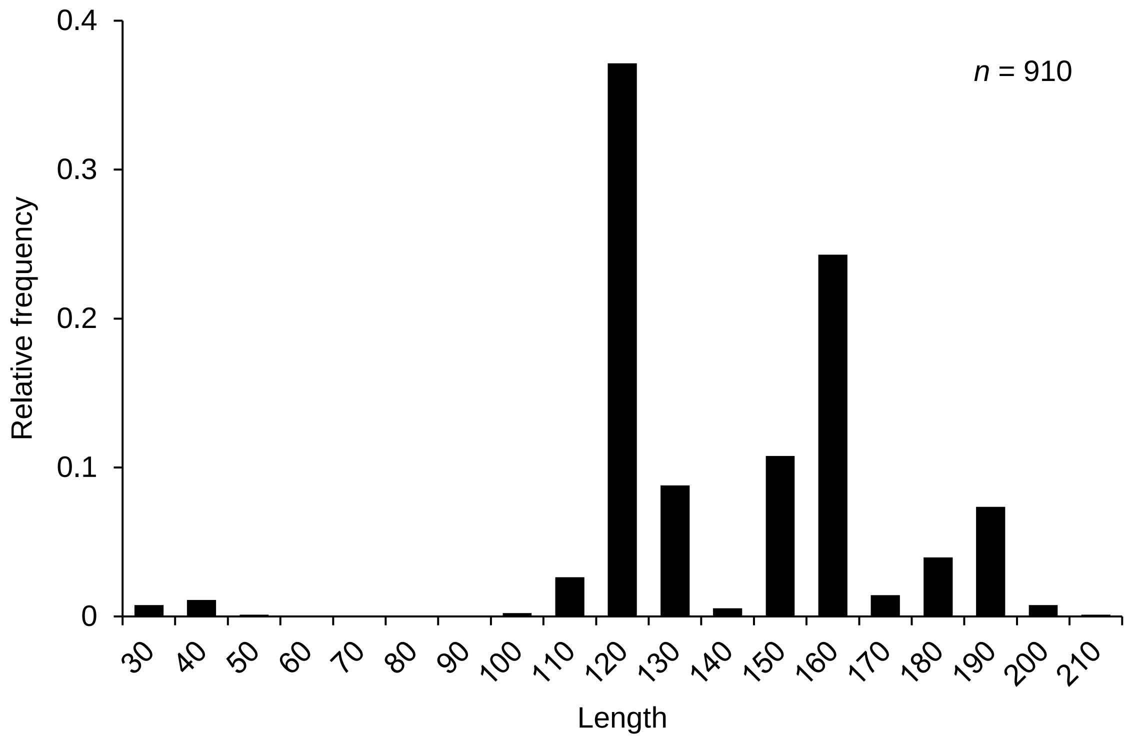

Figure 10. Length-frequency distribution for kokanee sampled using a modified-midwater trawl from Spirit Lake, Idaho (July 28, 2014).

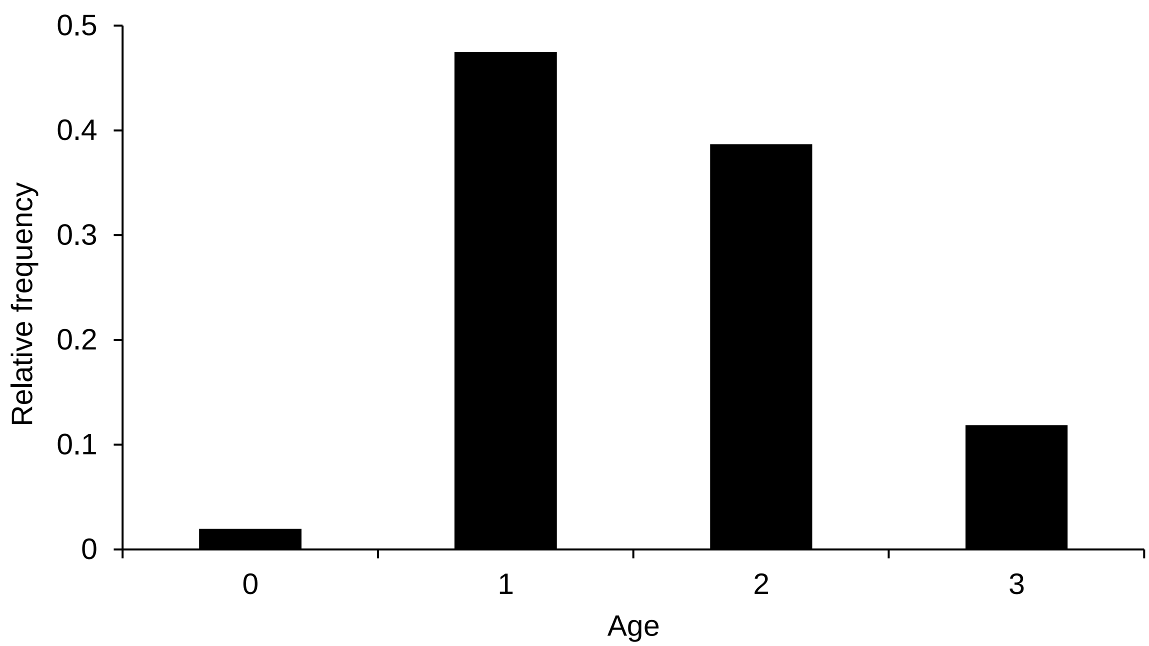

Figure 11. Age-frequency distribution for kokanee sampled using a modified-midwater trawl from Spirit Lake, Idaho (July 28, 2014).

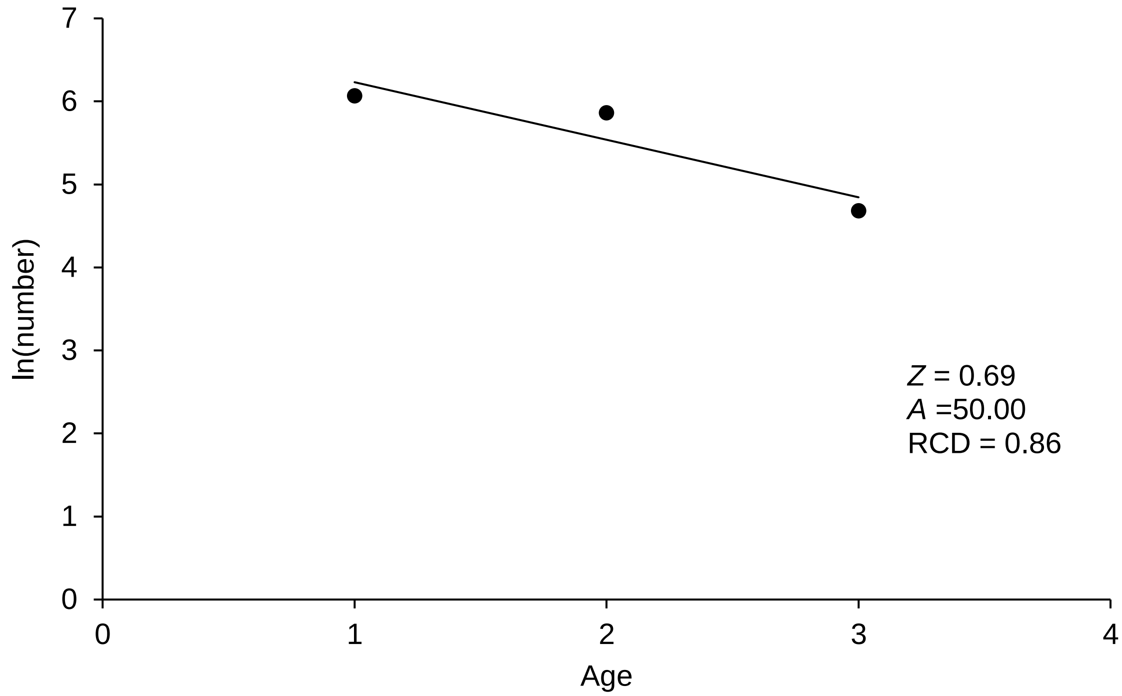

Figure 12. Catch curve regression estimating mortality and recruitment variability for kokanee sampled from Spirit Lake, Idaho.

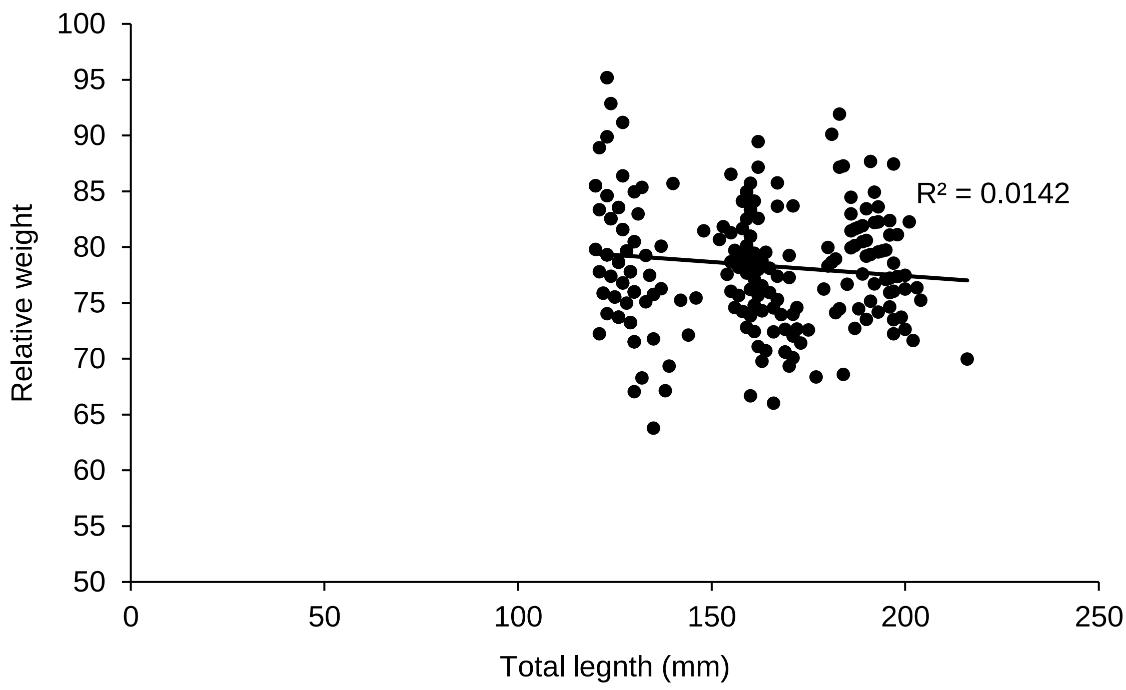

Figure 13. Relationship between total length and body condition of kokanee sampled from Spirit Lake, Idaho.

LAKE COEUR D'ALENE CHINOOK SALMON EVALUATIONS

ABSTRACT

We estimated population characteristics and escapement of Fall Chinook Salmon *Oncorhynchus tshawytscha* to assess trends in adult abundance and provide baseline population information. Chinook Salmon were sampled through a program, which relied on local anglers. Anglers sampled a total of 144 Chinook Salmon from the fishery during June–December 2014. This sample was supplemented with 27 Chinook Salmon spawners collected during redd surveys in index reaches of the Coeur d'Alene River during October 2014. We back-calculated mean length-at-age and used that information to estimate growth. We found that Chinook Salmon grow very quickly and reach the 508 mm minimum-length limit by age-2. Age structure of spawners varied from 3–5 years with the majority (77.3%) spawning at age-4. As such, most individuals are available for harvest for about 2 years. We observed the highest adult escapement during 2014 since redd monitoring began in 1990. We counted a total of 179 redds in the Coeur d'Alene and St. Joe Rivers. Of those, 170 were observed in the Coeur d'Alene River, whereas 9 were observed in the St. Joe River. While redd abundance in the St. Joe River has remained relatively stable over the past five years, redd abundance in the Coeur d'Alene River has increased steadily. Future assessments should include monitoring of adult escapement and spawner age structure so that critical thresholds of adult abundance may be identified. High abundance of adult Chinook Salmon could have negative implications for pelagic prey (i.e., kokanee *O. nerka*), and thus influence the quality of both fisheries. Information related to population characteristics will be used to assess potential rule changes to improve angler opportunity.

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INTRODUCTION

Chinook Salmon *Oncorhynchus tshawytscha* are an anadromous Pacific salmon species historically found throughout the Columbia River Basin (Wallace and Zaroban 2013). While anadromy is the natural life history form of Chinook Salmon, they have been successfully stocked into lentic systems outside of their native distribution where they carryout adfluvial life histories. For example, both Chinook Salmon and Coho Salmon *O. kisutch* have been stocked into large lakes and reservoirs in the northern United States where they have naturalized and provide angling opportunities (Diefenbach and Claramunt 2013; MFWP 2013). With adequate fluvial spawning habitat, many landlocked Pacific salmon populations are able to adopt adfluvial life history strategies and naturalize in lentic systems, persisting well outside of their native range.

Fall Chinook Salmon were first stocked into Lake Coeur d'Alene in 1982 as a biomanipulation tool to reduce kokanee *O. nerka* abundance. Kokanee exhibit density-dependent growth, and increases in population abundance commonly result in decreased length-at-age. This relationship has been evident in Lake Coeur d'Alene; Fishery managers noted declines in size structure of kokanee during the late 1970s concluded that harvest-related mortality was insufficient for driving abundances. Goodnight and Mauser (1980) recommended an increase in the daily bag limit of kokanee from 25 to 50 fish following the 1979 season. The following year, Mauser and Horner (1982) noted that "the population size still exceeded the capacity of the system to produce fish of a desirable size to anglers" and recommended that predators be used to reduce abundance. Although kokanee harvest had reached an all-time high of ~578,000 fish harvested in 1979, managers were convinced that improvements in size structure were needed to maintain angler interest. The semelparous life history and short life span of Chinook Salmon made it a desirable predator, and it was thought that their abundance could be regulated by stocking alone. An added benefit of Chinook Salmon was the creation of an additional fishery in the lake. Previous managers had no expectation of naturalization and wild reproduction from Chinook Salmon introduced into Lake Coeur d'Alene. However, Chinook Salmon were observed spawning in Wolf Lodge Creek as early as 1984 and wild fish had become common in the fishery by 1986. Wild Chinook Salmon redds were observed in the Coeur d'Alene River and St. Joe River around 1988, and by then, wild fish dominated the angler catch.

The Idaho Department of Fish and Game (IDFG) continues to utilize Chinook Salmon as one tool for managing the kokanee population in Lake Coeur d'Alene. In addition, stocking supplements the fishery by providing additional harvest opportunity. The IDFG's management objective regarding Lake Coeur d'Alene has been to maintain predator stocking at a rate that does not depress the kokanee population, yet helps to achieve kokanee size structure objectives. Combinations of redd excavation and stocking (or lack thereof) have been used to regulate abundance for Chinook Salmon. Estimates of wild production have been obtained by coupling redd survey information with known egg-fry survival rates; subsequently, redds have been destroyed during some years to bring estimated production in line with objectives. Historically, Chinook Salmon redd objectives have been 100 total redds among both the Coeur d'Alene and St. Joe Rivers. During years when the objective was exceeded, redds have been excavated, and supplemental stocking has been used during years when wild redd abundance was below objective. However, the effectiveness of managing adult Chinook Salmon densities using supplemental stocking and redd excavation has been unsubstantiated. In addition, the kokanee population appears to be influenced more by environmental conditions rather than predator abundance. As such, in recent years the IDFG has not excavated Chinook Salmon redds, but monitors trends in redd abundance and supplemental stocking has been maintained at ~ 20,000 individuals annually since 2010 to supplement harvest.

One factor that has influenced the IDFG's ability to control adult Chinook Salmon abundance in Lake Coeur d'Alene is related to performance and retention of hatchery fish. Although 20,000 hatchery Chinook Salmon are stocked annually, return-to-creel of hatchery fish is very low. Creel surveys conducted at angling tournaments and anecdotal evidence from avid Chinook Salmon anglers suggests that recruitment of hatchery fish to the fishery is close to zero. Maiolie and Fredericks (2014) evaluated performance of hatchery Chinook Salmon among rearing hatcheries and between Spring and Fall stocking seasons. The authors reported that hatchery fish performance may be lower among cohorts that where raised at Nampa Fish Hatchery and released in spring stocking groups. These results have influenced current management and the IDFG now rears supplemental Chinook Salmon for Lake Coeur d'Alene at Cabinet Gorge Hatchery in Clark Fork, Idaho. In addition, stocking has been moved to early Fall (i.e., late September or early October) when fish are larger. Anglers have reported that hatchery Chinook Salmon (identified by a clipped adipose fin) were more commonly encountered during 2013–2014 suggesting that those individuals are now recruiting to the fishery at higher rates, but perhaps still at lower rates than desired by managers.

Because Chinook Salmon occur naturally with anadromous life histories, it is likely that many attempt to emigrate shortly after release. Pacific Salmon demonstrate strong homing behavior and life history fidelity; however, effective imprinting of smolts may be used to overcome this tendency. By simulating migration from a lotic to lentic environment, we may be able to impose an adfluvial life history on hatchery stock. Mimicking a migratory life history and imprinting juveniles to a fluvial, "natal" environment is critical for retaining anadromous fishes in landlocked lakes. For example, Alaska Department of Fish and Game (ADFG) stocks surplus Chinook and Coho Salmon smolts into small natural lakes that are managed as put-grow-and-take fisheries (Havens et al. 1987).The ADFG has documented low retention of individuals stocked directly into lakes. In contrast, ADFG has obtained higher retention and higher return-to-creel among groups that are held in lake tributaries, imprinted, and allowed to emigrate to their respective lake where they subsequently spend their adult life history (Havens et al. 1987). A similar phenomenon may be occurring among hatchery Chinook Salmon stocked into Lake Coeur d'Alene, but a sound experimental design is needed to evaluate in-lake and tributary stocking strategies. Another possibility is that emigration issues may be overcome by using the Lake Coeur d'Alene broodstock similar to previous years.

Both kokanee and Chinook Salmon provide popular fishing opportunities in Lake Coeur d'Alene. The IDFG's objective for Lake Coeur d'Alene is to manage for a kokanee yield fishery (15 fish daily bag limit) and limited trophy Chinook Salmon fishery (2 fish daily bag; none under 508 mm). Prior to the introduction of Chinook Salmon, nearly all (~ 99%) of the angling effort in Lake Coeur d'Alene has been targeted at kokanee (Rieman and LaBolle 1980); however, more recent studies have shown that most effort (~ 66%) is now targeting Chinook Salmon (Fredericks et al. 1997). Chinook Salmon are highly sought by anglers because they often grow to very large sizes and have very palatable flesh. In fact, Chinook Salmon angling is now a dominant component of the Lake Coeur d'Alene fishery. Despite the high angling effort targeted at Chinook Salmon, however, little is known about dynamic rate functions and factors regulating the population. Managing both Chinook Salmon and kokanee populations in Lake Coeur d'Alene to provide a sustainable fishery is a priority for the IDFG. As such, a complete understanding of Chinook Salmon population dynamics in Lake Coeur d'Alene is critical for providing quality angling opportunities.

OBJECTIVES

1. Evaluate population characteristics of the Chinook Salmon population in Lake Coeur d'Alene.

2. Monitor trends in Chinook Salmon escapement.

3. Evaluate stocking strategies for hatchery Chinook Salmon to improve return-to-creel of supplemental fish.

STUDY AREA

Lake Coeur d'Alene is a natural mesotrophic water body located in the Panhandle of northern Idaho (Figure 14). Lake Coeur d'Alene lies within Kootenai and Benewah Counties and it is the second largest natural lake in Idaho with a surface area of 12,742 ha, mean depth of 24 m, and maximum depth of 61 m (Rich 1992). The Coeur d'Alene River and St. Joe River are the major tributaries to Lake Coeur d'Alene; however, many smaller second and third order tributaries contribute flow as well. The outlet to Lake Coeur d'Alene is the Spokane River, a major tributary to the Columbia River. Water resource development in the watershed includes Post Falls Dam, which was constructed on the Spokane River in 1906, and raised the water level approximately 2.5 m. In addition to creating more littoral habitat and shallow-water areas, the increased water level created more pelagic habitat for open-water salmonids (e.g., kokanee, Chinook Salmon).

The fish assemblage in Lake Coeur d'Alene is composed of three native sport fish species, five native nongame species, 16 introduced sport fish species, and one introduced nongame species. The fishery in the lake, however, can be broadly summarized as belonging to one of three components: kokanee, Chinook Salmon, or littoral species; all of which are popular among anglers. Increased fish assemblage complexity has undoubtedly resulted in increased biological interactions, but also diversified angling opportunity. Because of its close proximity to several major cities (i.e., Coeur d'Alene; Spokane, Missoula), Lake Coeur d'Alene generates high angling effort, contributing considerably to both state and local economies. In fact, according to a 2011 survey of the economic impact of angling in Idaho, Lake Coeur d'Alene generated ~ $11 million and 84,000 angler trips (IDFG, unpublished data).This number of angler trips was third in the state behind CJ Strike Reservoir and the famed Henrys Fork of the Snake River in eastern Idaho.

METHODS

Population characteristics

Because of the inherent difficulties associated with sampling pelagic freshwater fishes, we instituted an angler reporting program (ARP) to obtain Chinook Salmon samples from anglers. Chinook Salmon anglers were informed of the ARP by IDFG staff during angler club meetings and tournaments. Each volunteer was outfitted with sampling equipment and trained on basic sampling techniques. Anglers were instructed to record origin (i.e., hatchery or wild), total length (TL; mm), weight (g), and remove age estimation structures. Many anglers harvest Chinook Salmon regularly; however, others tend to be non-consumptive or only harvest large individuals. To overcome this issue, we provided options for obtaining hard structures while allowing the angler to harvest or release the fish as he/she wished. For harvested fish, anglers were instructed to remove the head by cutting posterior to the pectoral fins, leaving them attached. For released fish, anglers were instructed to remove the left leading pectoral fin ray by cutting immediately distal to the articulating process near the body wall (Koch et al. 2008). Chinook Salmon heads obtained from harvested individuals were processed by IDFG staff in the laboratory. Ototliths were extracted using the “up-through-the-gills” method described by Scheidervin and Hubert (1986) and cleaned of tissue. Pectoral fin rays from harvested individuals were removed using the same method as anglers to maintain consistent removal methodology.

Hard structures were allowed to air dry for several weeks prior to processing .Pectoral fin rays were mounted in epoxy using 2 mL microcentrifuge tubes following Koch and Quist (2007). Cross sections (0.9-mm thick) were cut near the base of each pectoral fin ray just distal to the articulating process using an IsoMet 1000 precision saw (Buehler, Inc., Lake Bluff, Illinois, USA). Transverse sections (0.6-mm thick) of otoliths were also cut using a low-speed saw with sections bracketing the nucleus. Resulting cross sections for both hard structures were viewed using a dissecting microscope with transmitted light and an image analysis system (Image ProPlus; Media Cybernetics, Silver Springs, Maryland, USA). Sections were polished with 1,000-grit sandpaper and covered with a single drop of immersion oil to improve clarity during reading.

We corroborated age estimates and structure clarity from a subsample of otoliths and pectoral fin rays. Pectoral fin rays consistently produced the most precise age estimates and had the most defined annulus formation. Because pectoral fin rays were removed from harvested and released fish alike, they were available for all individuals in our sample. Thus, we proceeded using only pectoral fin rays for all subsequent age and growth determinations.

Body condition of Chinook Salmon was evaluated using relative weight (W_r; Neumann et al. 2012).Relative weight values were calculated as

$$W_r = (W / W_s) \times 100,$$

where W is the weight of an individual and W_s is the standard weight predicted by a species-specific length-weight regression (Neumann et al. 2012). A W_r value of 100 indicates average body condition, W_r values below 100 indicate poor body condition, and W_r values above 100 indicate good body condition.

Mean back-calculated lengths at age were estimated using the Dahl-Lea direct proportion method (Quist et al. 2012)

$$L_i = L_c \times (S_i / S_c),$$

where L_i is the length at annulus i, L_c is the length at capture, S_i is the fin ray radius at annulus i, and S_c is the fin ray radius at capture.

<u>Spawner abundance and age structure</u>

Chinook Salmon escapement has been monitored using redd surveys in the Coeur d’Alene River and St. Joe River since 1990. Predetermined index reaches (Table 3) have been sampled annually during late September–early October to estimate relative redd abundance. Early surveys were done via helicopter, but since 2012 surveys have been conducted using canoes (Maiolie and Fredericks 2014). Two canoeists floated the Coeur d’Alene River index reaches during October 2–3, 2014 and the St. Joe index reach during October 6, 2014. During sampling, each redd was enumerated and georeferenced with a global positioning system. In addition, the area around each redd was observed for live Chinook Salmon and carcasses. Intact carcasses were measured for TL and hard structures were removed and processed similar to methods described above. Redd abundance was estimated as the total number of redds observed among all index reaches. We compared among previous years' surveys to provide insight on trends in abundance.

Performance of supplemental Chinook Salmon

Eggs from Tule Fall Chinook Salmon were purchased from Big Creek Fish Hatchery located near Astoria, Oregon, and were hatched and reared at Cabinet Gorge Hatchery in Clark Fork, Idaho. The adipose fin was completely removed from all individuals (n = 18,978), but they were not tagged as in previous years. Approximately 10,000 individuals (i.e., tributary group) were held in 2 submerged live cages (1.0 × 2.4 m) under the I-90 bridge in Wolf Lodge Creek (Figure 13) for 10 days prior to release on September 25, 2014. The remaining individuals (i.e., in-lake group) were stocked on October 3, 2014 when water temperatures were similar to that of the tributary group. Relative return-to-creel will be evaluated using adults sampled via the ARP and during angling tournaments in future years.

Specific comparisons between stocking groups will require sampling of known-origin (stocking group) adults. As such, future stocking groups will require unique marks for purposes of differentiated among groups and years. To address this, the in-lake and tributary stocking groups will be uniquely thermal marked by Cabinet Gorge Hatchery staff. Analysis of variance (ANOVA) with post-hoc multiple comparisons will likely be used to compare return-to-creel among years and between stocking groups.

RESULTS

Population characteristics

A total of 186 Chinook Salmon were sampled during June–December, 2014. Of those, 27 were spawners sampled during redd count surveys, 15 were sampled during angling tournaments, and 144 were sampled through the ARP. Chinook Salmon spawners sampled during redd counts varied in length from 554–905 mm and varied in age from 3–5 years. Chinook Salmon sampled through tournaments and the ARP varied in length from 305–889 mm and varied in age from 1–5 years (Figure 15).We combined growth data from spawners and angler-caught individuals to estimate growth. Mean back-calculated lengths-at-age had wide ranges among age-classes (Table 3), but overall were only slightly variable. Chinook Salmon grow very quickly in Lake Coeur d'Alene and most individuals reach the 508 mm minimum-length limit by age-2 (Figure 16). Body condition among angler-caught Chinook Salmon was good (mean W_r = 92.0; SE = 1.4), and body condition showed an increasing trend in relation to total length (Figure 17).

Spawner abundance and age structure

We summarized redd abundance to provide insight on adult escapement and to monitor trends in natural production. We observed a total of 170 redds in the Coeur d'Alene River basin. Of these, we observed 104 redds in the mainstem Coeur d'Alene River between Cataldo and the confluence of the South Fork Coeur d'Alene River, 62 redds in the North Fork Coeur d'Alene River between the confluence of the South Fork Coeur d'Alene River and the confluence of the Little North Fork Coeur d'Alene River, and four redds in the South Fork Coeur d'Alene River between the mouth and Pine Creek (Table 4). A total of nine redds was observed in the St. Joe River between St. Joe City and the Calder Bridge (Table 4).Chinook Salmon redd abundances have shown an increasing trend over the past two years in the Coeur d'Alene River, and 2014 marks the highest redd abundance observed since monitoring began in 1990 (Figure 18).

Age structure of spawners was estimated from 27 Chinook Salmon sampled from the Coeur d'Alene River. The vast majority of individuals (77.3%) spawned at age-4, while the remaining individuals spawned at age-3 (13.6%) and age-5 (9.1%; Figure 19). Based on the current 508 mm minimum-length limit, individuals are available for harvest between one and three years.

DISCUSSION

The Chinook Salmon fishery has improved substantially over the past decade, and during 2014 anglers enjoyed some of the best fishing in recent history. The combination of several factors (i.e., stable environmental conditions, abundant kokanee forage) has likely allowed the wild portion of the population to rebound from the low abundances observed in the late 1990s. The most recent redd survey (Fall 2014) marked the highest redd abundance since monitoring began in 1990. Between 2007 and 2012, redd abundance was relatively stable, but there has been a sharp increase over the past few years. Anglers will likely benefit from the increase in Chinook Salmon abundance in the short-term; however, caution should be taken to avoid high predator abundance which could potentially alter the pelagic prey community.

Based on 2014's evaluation of Chinook Salmon population characteristics, individuals tended to be in good condition, grew quickly, and maintained relatively steady growth rates throughout their life. Individuals typically reach the 508 mm minimum-length limit at age-2 and are then available for harvest for one to three years based on spawner age-structure. Some anecdotal information, however, suggests that much of the harvest in composed of age-3 and age-4 Chinook Salmon. Although catch rates of age-2 Chinook Salmon can often be very high, individuals under 550–600 mm are often not harvested due to their small size. As such, we assume that much of the harvest may target age-3+ individuals, which are less catchable and very close to maturity.

The Chinook Salmon fishery in Lake Coeur d'Alene has historically been supported almost entirely by natural reproduction. This held true again during 2014, however several adipose-clipped individuals were observed in the Fall derbies. In addition, anecdotal evidence from anglers suggests that age-1 and age-2 adipose-clipped individuals were more common in the fishery this year. The IDFG has made the following advances in Chinook Salmon rearing and stocking, which may be contributing to improved performance of hatchery individuals: 1) Fall Chinook Salmon rearing has been moved from Nampa Hatchery to Cabinet Gorge Hatchery where rearing temperatures are colder and the transport distance to Lake Coeur d'Alene is shorter, and 2) size-at-release has been increased by switching from Spring to Fall stocking. The combination of changes in rearing and release timing are expected to improve survival of hatchery fish; however, we will be unable to fully-quantify the effect of these management actions until the individuals from the 2014 stocking recruit to the fishery. While the direct results of these actions are difficult to substantiate, we cannot attribute this change in occurrence of hatchery individuals to any other major management changes. This is consistent with previous studies showing that performance of hatchery fish is often directly related to length-at-release where larger individuals typically exhibit higher survival and return-to-creel than their smaller counterparts (Henderson and Cass 2011).

Despite ongoing efforts to identify factors influencing return-to-creel of hatchery-produced Chinook Salmon, the post-release fate of those individuals remains unknown. Previous research has addressed factors that limit survival (Maiolie et al. 2013; Maiolie and Fredericks 2014), but no work has sought to understand retention of hatchery-produced Chinook Salmon and whether post-release emigration may be a limiting factor. Future work will be aimed at evaluating relative return-to-creel by comparing stocking strategies that are hypothesized to improve retention.

Anglers often catch adipose-clipped Chinook Salmon in Lake Roosevelt, WA which presumably emigrated from Lake Coeur d'Alene and become entrained in that reservoir (Bill Baker, personal communication). These reports are common and are received from both anglers and Washington Department of Fish and Wildlife personnel. Post-release emigration has been documented in other lentic systems in Idaho where Fall Chinook Salmon are stocked. For instance, hatchery Chinook Salmon stocked into Deadwood Reservoir in the Southwest Region have been sampled in Black Canyon Reservoir on the Payette River (Koenig et al. 2015). Additionally, hatchery Chinook Salmon stocked into Anderson Ranch Reservoir have been reported in Arrowrock Reservoir and Lucky Peak Reservoir (Arthur Butts, personal communication). This raises serious concern about post-release retention of hatchery stock and its effect on return-to-creel. It is likely that Chinook Salmon from anadromous stocks have a strong tendency to emigrate after release, particularly when stocked into waters within the Columbia River Basin. The maintenance of this life history may lead to a substantial portion of the hatchery fish attempting to emigrate downstream after release. Improving retention will likely require the use of a method that imposes an adfluvial life history on hatchery individuals, or require the use of a landlocked, adfluvial stock (i.e., Lake Coeur d'Alene) for hatchery production.

MANAGEMENT RECOMMENDATIONS

1. Continue angler reporting program to address the following management objectives: 1) Evaluate various stocking strategies for hatchery Chinook Salmon, 2) evaluate return-to-creel of hatchery raised Chinook Salmon, 3) Monitor changes in dynamic rate functions related to management activities.

2. Continue to monitor Chinook Salmon spawner escapement at index reaches in the Coeur d'Alene River and St. Joe River.

3. Continue to thermal-mark hatchery Chinook Salmon to compare stocking future stocking strategies.

Table 3. Growth statistics for Chinook Salmon sampled from Lake Coeur d'Alene, Coeur d'Alene River, and St. Joe River (2014).

	Back-calculated length			
Age	Mean	Min	Max	SD
1	174.08	100.17	325.85	40.91
2	439.01	229.64	610.84	75.69
3	626.70	406.77	762.00	75.35
4	730.97	550.00	905.00	86.91
5	833.00	813.00	846.00	17.58

Table 4. Location, description of index reaches, and number of Chinook Salmon redds counted during surveys from the most recent five years. Surveys are conducted in the Coeur d'Alene River and St. Joe River. Reaches include only those with long time series information used to index Chinook Salmon redd abundance.

		Year				
Reach	Description	2014	2013	2012	2011	2010
	Coeur d'Alene River					
CDA 1	Cataldo to S.F. Coeur d'Alene River confluence	104	108	65	79	71
CDA 2	S.F. to L.N.F Coeur d'Alene River confluence	62	2	7	12	16
CDA 3	S.F. Coeur d'Alene River	4	14	13	17	8
	St. Joe River					
SJR 1	St. Joe City to Calder bridge	9	4	9	-	20

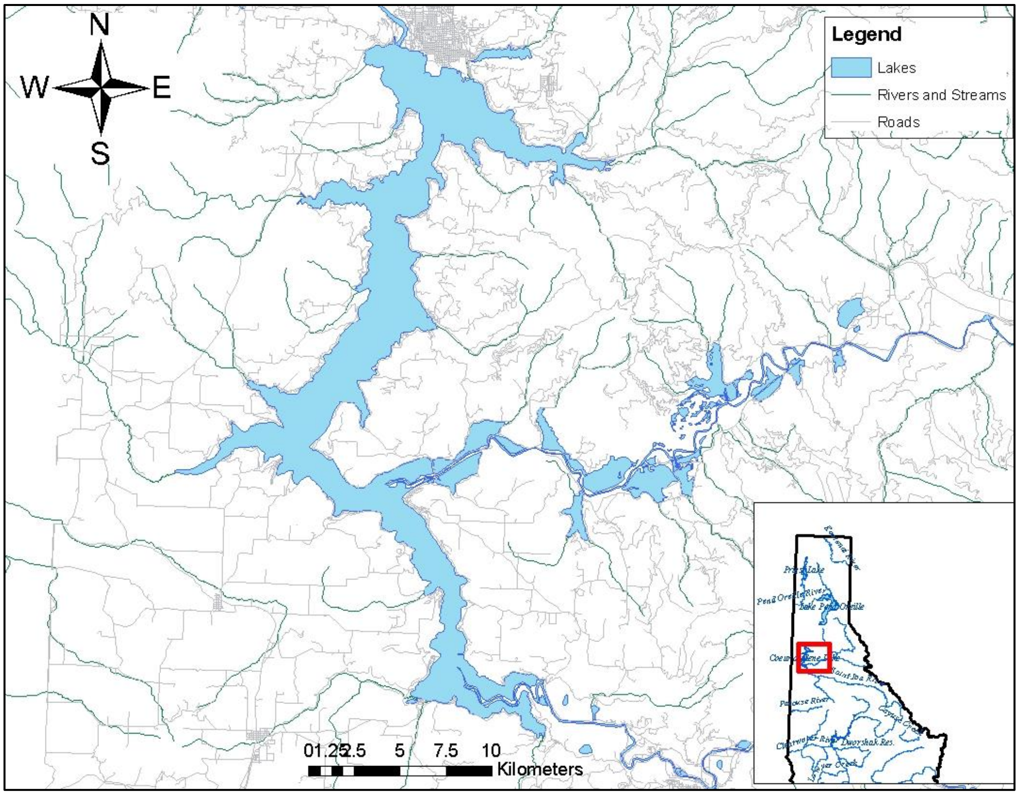

Figure 14. Location of Lake Coeur d'Alene, Idaho. The black dot represents the holding and release location of tributary-stocked hatchery Chinook Salmon.

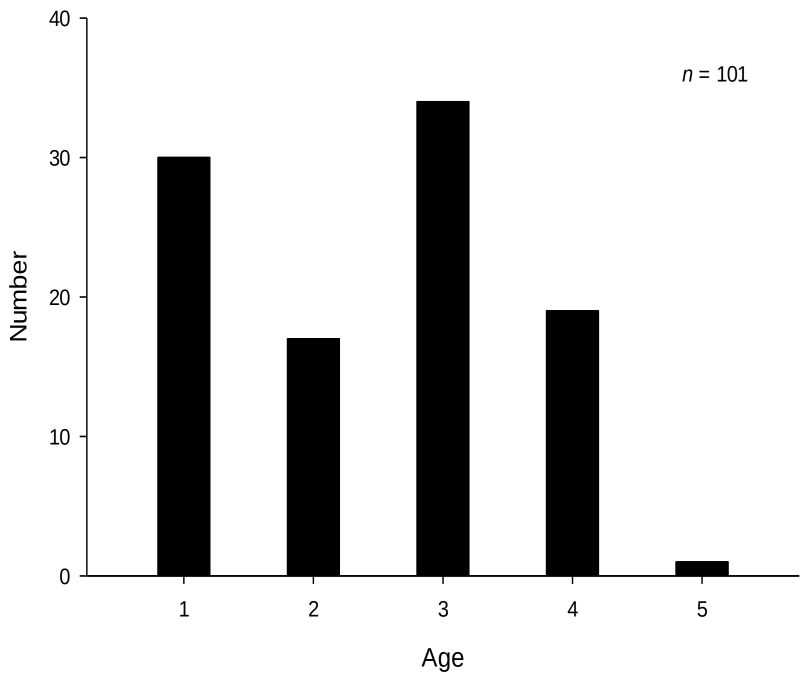

Figure 15. Age-frequency distribution for angler-caught Chinook Salmon sampled from the fishery in Lake Coeur d'Alene during June–December, 2014.

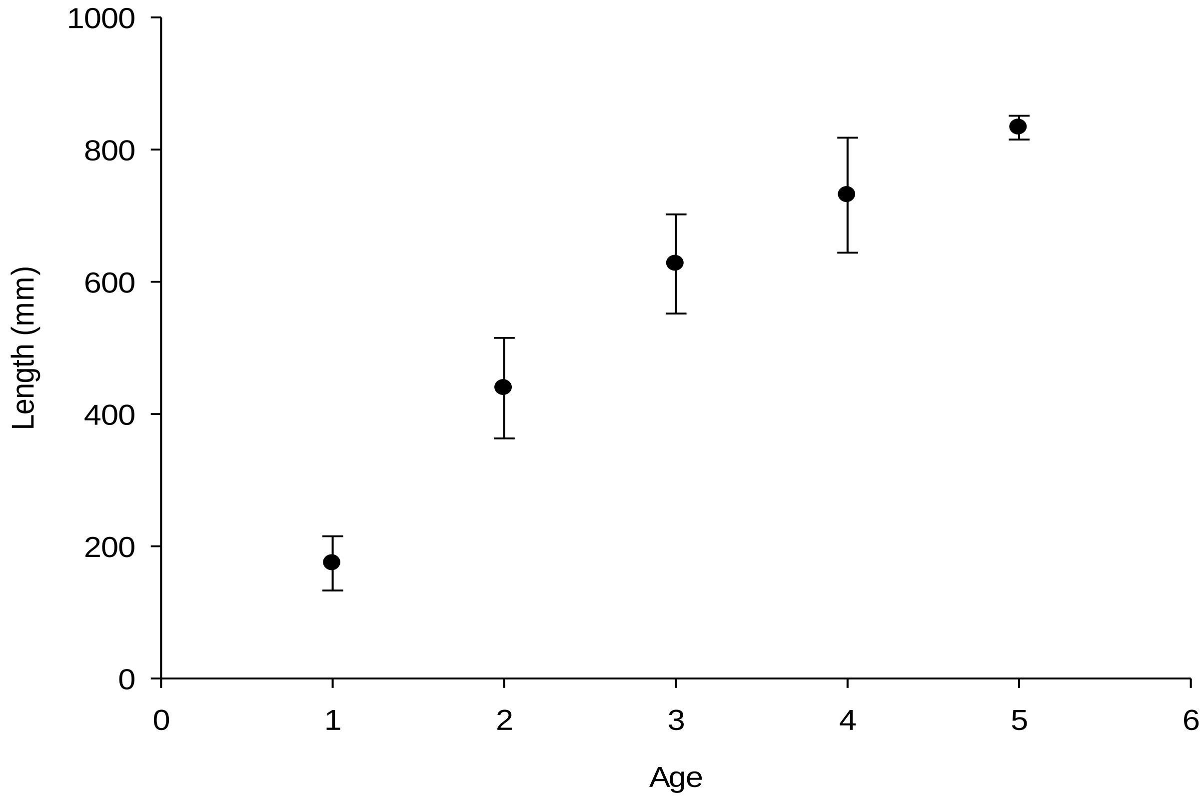

Figure 16. Mean back-calculated length-at-age for Chinook Salmon sampled in Lake Coeur d'Alene during 2014.Error bars represent the standard deviation of the mean.

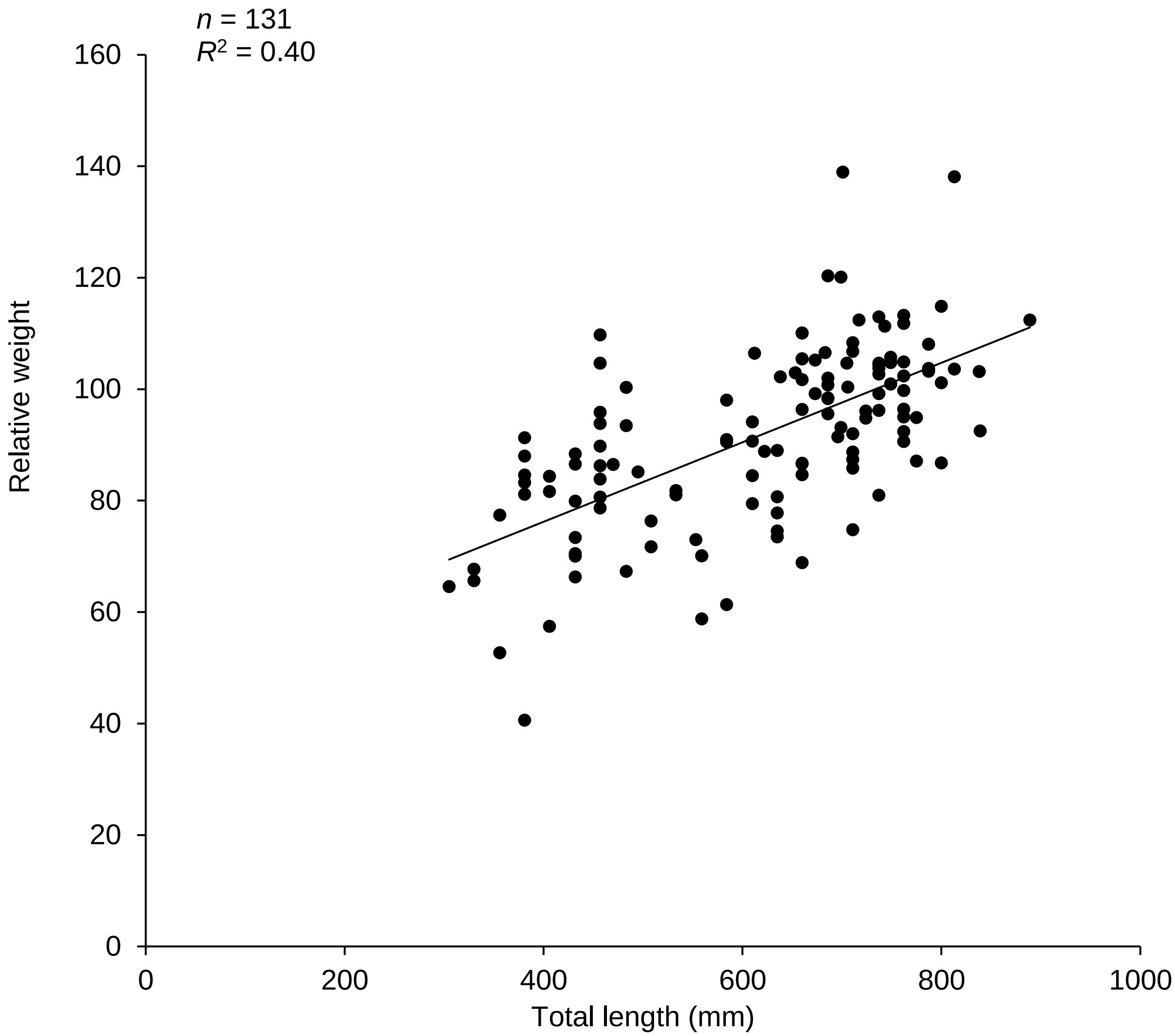

Figure 17. Relationship between total length and body condition of Chinook Salmon sampled from the fishery in Lake Coeur d'Alene during 2014.

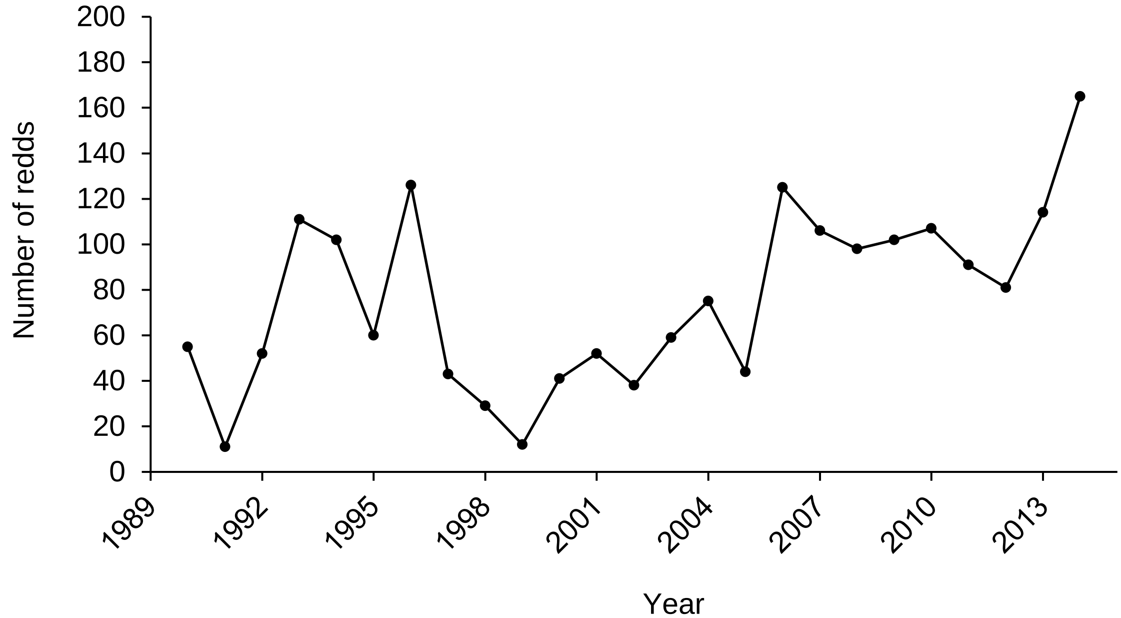

Figure 18. Number of Chinook Salmon redds counted during sampling of index reaches in the Coeur d'Alene River and St. Joe River from 1990–2014.

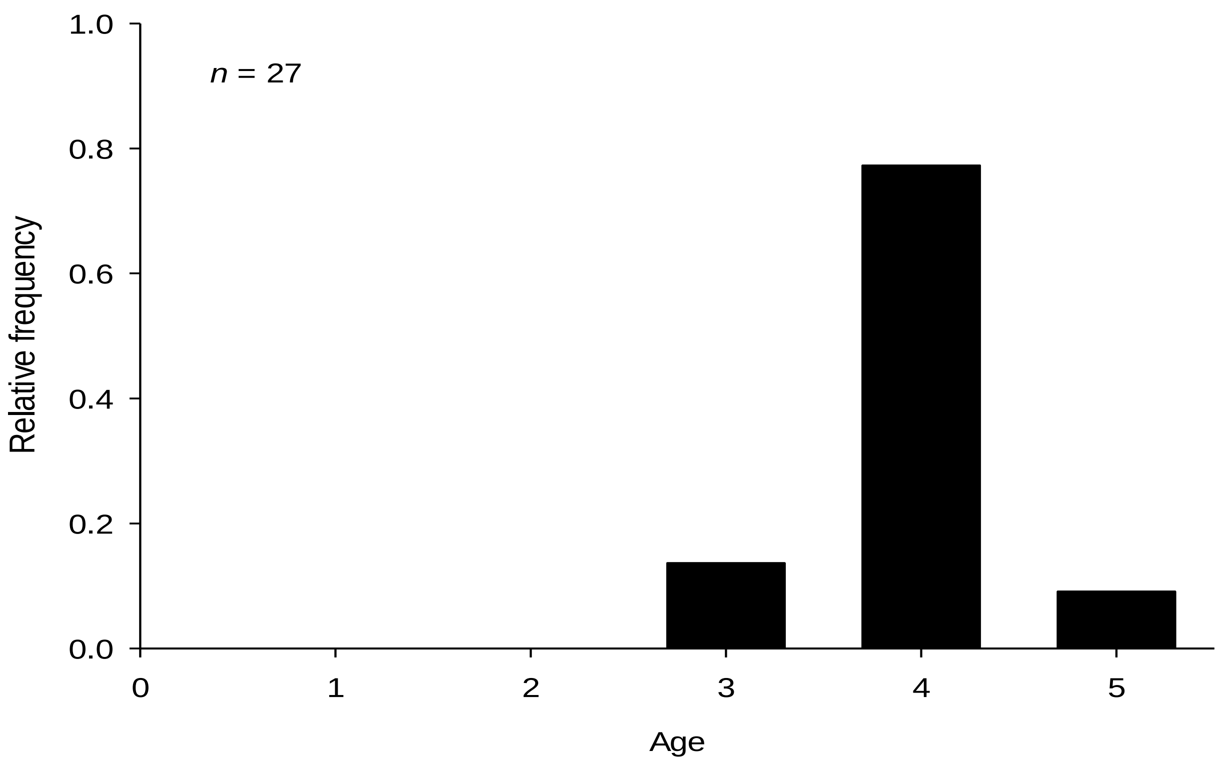

Figure 19. Age-frequency distribution for Chinook Salmon spawners sampled from the Coeur d'Alene River on October 2–3, 2014.

HAYDEN LAKE RAINBOW TROUT STOCKING EVALUATIONS

ABSTRACT

Hayden Lake, located northeast of Hayden Idaho in the Panhandle Region provides excellent fishing for multiple fish species and is popular fishing destination. Rainbow Trout *Oncorhynchus mykiss* have been stocked in Hayden Lake since the early 1900s and have historically provided a quality fishery, but represent only a small portion of the effort and catch in recent years. Identifying the cause and remedy for declining quality trout fishing opportunities in Hayden Lake has been an ongoing focus of fisheries managers, but with little improvement resulting in the fishery. In 2014, we attempted to evaluate survival of recent Rainbow Trout stocking events in Hayden Lake using standardized floating experimental gill nets to describe relative abundance of these fish in the lake post out plant. We also sampled zooplankton Hayden Lake to further investigate potential factors effecting survival of stocked fishes. We collected few Rainbow Trout in our sample suggesting abundance was low, but limiting our ability to compare stocking methods. We estimated average ZPR and ZQI at 0.81 (± 0.02, 80% CI) and 0.09 (± 0.01, 80% CI), respectively. Manipulations of timing and size of Rainbow Trout stocking should continue to determine a more appropriate stocking strategy. We recommend continued evaluation of these stocking events in an effort to determine the most appropriate stocking strategy and improve return to the fishery. Zooplankton monitoring suggested abundance was low, but cropping of preferred size zooplankton did not appear to be an issue. We recommend zooplankton quantity and quality continue to be monitored to ensure current stocking rates are suitable for maximizing growth of hatchery products including kokanee. We also recommend consistent annual sampling using standard methods to help limit variability between monitoring efforts.

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INTRODUCTION

Hayden Lake, located northeast of Hayden Idaho in the Panhandle Region provides excellent fishing for multiple fish species and is a popular destination for anglers. A mix of warm water species such as Largemouth Bass *Micropterus salmoides*, Black Crappie *Pomoxis nigromaculatus*, and Yellow Perch *Perca flavescens* introduced in the early 1900s are the primary focus of anglers (Maiolie et al. 2011). More recent sportfish introductions into Hayden Lake also provide popular fishing opportunities. Smallmouth Bass *Micropterus dolomieui*, legally introduced, and Northern Pike *Esox lucius*, illegally introduced, added to popular littoral fisheries (Maiolie et al. 2011). Kokanee *Oncorhynchus nerka* stocked since 2011 have noticeably increased angling effort in the pelagic areas of the lake. Historically, Hayden Lake provided a popular fishery for native Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, but cutthroat abundance has declined and now cutthroat are rare in the catch (Mauser 1978, Maiolie et al. 2011). Rainbow Trout have been stocked in Hayden Lake since the early 1900s and have historically provided a quality fishery, but represent only a small portion of the effort and catch in recent years presumably due to a decline in the quality of the fishery.

Identification of the cause and remedy for declining quality trout fishing opportunities in Hayden Lake has been an ongoing focus of fisheries managers. Multiple management actions have been attempted to increase trout survival and abundance and improve Hayden Lake recreational fisheries. Management actions have included introduction of freshwater shrimp *Mysis diluviana* an alternative food source, stocking rate manipulations and experimentation with stocked strains and stocking locations. Despite these efforts, angler catch rates on trout continue to be low (Maiolie et al. 2011).

We continued Rainbow Trout stocking investigations as further effort to maximize return to the Hayden Lake fishery. Most recently, the timing of stocking events and the size of stocked Rainbow Trout fingerlings has been the focus of efforts to improve the Hayden Lake trout fishery. Rainbow Trout fry, fingerlings, and catchables have been stocked during both spring and fall periods. We have evaluated relative return from spring and fall fingerling stocking strategies by describing relative abundance of Rainbow Trout in Hayden Lake. In continuation of this evaluation, a survey of Rainbow Trout relative abundance was completed in 2014. Survival of stocked fingerling Rainbow Trout can be influenced by the presence of larger zooplankton (Dillon 1996). To further investigate potential influences of zooplankton quality and quantity on survival of stocked fishes, we also conducted zooplankton sampling in Hayden Lake.

OBJECTIVES

1. Determine appropriate Rainbow Trout stocking strategies for maximizing stocked fish survival and return to the creel in Hayden Lake

2. Evaluate zooplankton quality and quantity to assess forage availability for stocked fingerling trout

METHODS

We sampled fish from Hayden Lake using IDFG standardized floating experimental gill nets. Twelve nets were fished overnight between April 14, 2014 and April 18, 2014. Net set locations were randomly selected throughout the lake (Table 5).

Captured fish were recorded by net location. We identified all fish, measured to total length (mm), and checked for marks. We reported mean catch per unit effort (CPUE [fish/net night) as a measure of relative abundance in the lake. We intended to use proportional differences in relative abundance to explore the success of different stocking groups. We anticipated encountering multiple stocking groups including, large Rainbow Trout fingerlings stocked in September 2011 (≥ 152 mm, adipose clipped), fingerlings stocked in June 2012 (76 mm to 152 mm, no mark), catchables stocked in June 2012 (> 152 mm, no mark), and large fingerlings stocked in October 2013 (≥ 152mm, no mark). Although marks were not available to distinguish every stocking group, length differences were anticipated to allow course separation.

Zooplankton were collected on August 20, 2014 using a 150-µm mesh net. A single sample was taken six randomly selected locations from a depth of 9 m. The samples were preserved in denatured ethyl alcohol at a concentration of 1:1 (sample volume: alcohol). After approximately ten days in alcohol, phytoplankton were removed from the samples and each sample was sieved through a 750-µm and 500-µm mesh. Each sample was blotted dry and weighed to the nearest gram (wet weight).

We summarized zooplankton quality and quantity using the zooplankton productivity ratio method (ZPR) and the zooplankton quality index (ZQI) as defined by Teuscher (1999). ZPR was calculated as the ratio of preferred to usable zooplankton (750:500 µm). ZQI was calculated ((500 + 750µm)ZPR). Total density of zooplankton was described as the weight of collected zooplankton in the 153-µm net corrected for sample tow depth (g/m). Values were reported as means representing all sites sampled.

RESULTS

We caught few Rainbow Trout among all net locations, with a total collection of two fish (Catch-per-unit-effort (CPUE) = 0.2; Table 6). Sampled Rainbow Trout were 365 and 510 mm. The largest fish sampled also was marked with a clipped adipose fin indicating it was stocked as a large fingerling in 2011. Based on the observed growth of the adipose clipped fish we speculated the second Rainbow Trout caught was stocked as a fingerling in 2012. We measured surface water temperatures during the survey at 7 to 8 °C.

Gill nets also captured Brown Bullhead *Ictalurus nebulosus*, Black Crappie, Bluegill *Lepomis macrochirus*, kokanee *Oncorhynchus nerka*, Northern Pike, Pumpkinseed *Lepomis gibbosus*, and Yellow Perch *Perca flavescens*. CPUE (± 80% CI) was highest for Black Crappie, Pumpkinseed, and Kokanee. However, kokanee (CPUE, 1.9 ± 0.5) and Northern Pike (CPUE, 1.1 ± 0.9) were captured most consistently among all sets. Kokanee CPUE was lower than observed in 2013 (2.5 ± 1.9), but overlapping confidence bounds suggested differences were not significant.

Average zooplankton density (± 80% CI) for Hayden Lake was 0.01 g/m (± > 0.01). We estimated average ZPR and ZQI at 0.81 (± 0.02) and 0.09 (± 0.01), respectively.

DISCUSSION

The low CPUE of Rainbow Trout in our sample effort suggested stocked Rainbow Trout from recent stocking events were not abundant in Hayden Lake. We were unable to determine differences in the relative contribution of stocking events and concluded that survival was likely poor for all recent stocking events. Anecdotally, angler reports suggest Rainbow Trout harvest remains low, supporting our observations and providing some indication angling effort and associated harvest was not the primary cause of low survival.

Although we collected few Rainbow Trout, bycatch suggested our selected gear type was suitable for capturing pelagic oriented fish such as kokanee and Rainbow Trout. Kokanee were one of the most abundant fish in the catch and were similar in size to that expected of Rainbow Trout from the targeted stocking events. Based on the catch of Kokanee we conclude net mesh sizes were likely suitable to capture Rainbow Trout. We assumed Rainbow Trout to be surface oriented in pelagic waters due to cool water temperature during our sample period and therefore vulnerable to floating gill nets. The presence of kokanee in our catch also lends some credibility to this assumption. However, recent sampling experiences on other regional waters suggested water temperatures above 13 °C experienced later in the spring may improve recruitment to the gear for trout in lentic waters (Ryan et al., this report). We recommend adding an alternate sampling effort when temperatures are near 13 °C to better understand how sample timing may effect out survey results.

We recommend continued evaluation of Rainbow Trout size at stocking and its effect on survival and return to the creel in Hayden Lake. Our results provided some evidence that survival of stocked fingerling Rainbow Trout in Hayden Lake was low. However, angler reports following fall fingerling out plants in 2011 provided some evidence these fish recruited to the fishery in years past. In addition, tag returns from catchable sized (> 250 mm) Rainbow Trout stocked in Hayden Lake in 2011 estimated over 30% of stocked catchable size fish were caught by anglers (IDFG unpublished data). Based on these observations we recommend continued evaluation of fish size at stocking including both large fall fingerling and catchable size Rainbow Trout. We also recommend batch marking be employed to enhance our ability to identify specific stocking groups.

Zooplankton biomass and ZQI values indicated zooplankton in Hayden Lake were in low abundance. Although abundance was estimated to be low, cropping of preferred size zooplankton did not appear to be an issue. ZPR values >0.60 were considered to represent robust proportions of preferred size zooplankton, while biomass and ZQI values less than 0.10 represented very low abundance (Teuscher 1999). Our results represented a decline in estimated biomass and ZQI from previous monitoring efforts in 2010 and 2011, but were consistent with previously estimated ZPR values (Maiolie et al. 2011, Fredericks et al. 2013). While our estimate provides some indication zooplankton abundance may have changed, the overall interpretation of low abundance was consistent in three all surveys.

Consistent observations of robust proportions of preferred size zooplankton between survey years suggested current stocking rates or wild abundance of planktivorous fishes in Hayden Lake are not limiting zooplankton. However, some consideration should be given to current stocking rates based on the very low estimate of biomass in 2014. Teuscher (1999) suggested fingerling stocking rates of 75 fish per hectare or catchables be used when ZQI values are measured at >0.10. Rainbow Trout fingerlings have been stocked in Hayden Lake at low levels (approximately 13 fish/ha) well below the suggested level for current zooplankton densities (IDFG, unpublished data). However, Kokanee fry were introduced to Hayden Lake in 2011 and have been stocked at rates of 65–100 fish/ha (IDFG, unpublished data). General observations of kokanee growth have not suggested forage is limited, with angler-caught fish reaching 400 mm to 450 mm. We recommend zooplankton quantity and quality continue to be monitored to insure current stocking rates are suitable for maximizing growth of hatchery products including kokanee.

Biomass and ZQI values may be considerably variable within and between months as demonstrated by Fredericks et al. (2013). Our zooplankton sampling effort was conducted on one day in August. In addition, our survey methods differed slightly from those recommended by Teuscher (1999). We sampled with only one small mesh net, sieving samples in the lab to sort zooplankton sizes. Our method was altered due to equipment failure. Although we had no specified concern regarding this method, a more consistent approach would lend more confidence in our results. We recommend consistent annual sampling using standard methods to help limit variability between monitoring efforts.

MANAGEMENT RECOMMENDATIONS

1. Continue to evaluate survival of large (≥ 152 mm) fall fingerling and catchable (> 250 mm) Rainbow Trout stocking efforts by describing relative abundance in Hayden Lake during the spring
2. Use batch-marked fish to identify specific stocking groups
3. Assess survey timing to improve gear effectiveness
4. Continue monitoring zooplankton quality and quantity in association with stocking rates in an effort to maximize growth of stocked fish
5. Maintain consistent annual sampling using standard methods to limit variability between monitoring efforts.

Table 5. Date, time (hours), and location (UTM) of gill net sets from 2014 Hayden Lake gill netting completed to evaluate Rainbow Trout stocking.

Date Set	Net	Time	Datum	Z	E	N
4/14/14	1	14:44	WGS84	11	519060	5290270
4/14/14	2	14:50	WGS84	11	519160	5288691
4/14/14	3	14:50	WGS84	11	520747	5289202
4/14/14	4	14:57	WGS84	11	523567	5290546
4/14/14	5	14:58	WGS84	11	523107	5292078
4/14/14	6	15:05	WGS84	11	523090	5293725
4/17/14	7	16:15	WGS84	11	518563	5288678
4/17/14	8	15:45	WGS84	11	520285	5289324
4/17/14	9	16:26	WGS84	11	523573	5289530
4/17/14	10	14:50	WGS84	11	521931	5291157
4/17/14	11	16:20	WGS84	11	523082	5292797
4/17/14	12	16:20	WGS84	11	522979	5295457

Table 6. Species, minimum and maximum total length (TL), catch (*n*), and catch rate (CPUE fish/net night) from 2014 Hayden Lake gill netting completed to evaluate Rainbow Trout stocking.

Species	Min TL	Max TL	*n*	CPUE
Black Crappie	119	254	34	2.8
Bluegill	135	178	2	0.2
Brown Bullhead	275	312	10	0.8
Kokanee	176	409	23	1.9
Northern Pike	358	972	13	1.1
Pumpkinseed	97	175	32	2.7
Rainbow Trout	365	510	2	0.2
Yellow Perch	144	199	13	1.1

HAYDEN LAKE NORTHERN PIKE ANGLER EXPLOITATION

ABSTRACT

Northern Pike were illegally introduced into Idaho's Coeur d'Alene Lake system in the early 1970s. Since that introduction, they've been illegally transferred to other northern Idaho waters, but their distribution to date in Idaho is restricted to the five northern counties. Northern Pike have created some of the region's more popular fisheries. General observations in most Idaho Northern Pike waters have suggested fishing regulations combined with environmental conditions limit Northern Pike abundance and minimize the potential impact to native and other game fish. Northern Pike in Hayden Lake are assumed to be relatively low in abundance and experience high annual angling mortality, though estimates of these variables have not been completed. Our objective was to investigate Northern Pike exploitation in Hayden Lake and provide insight on the influence of angling mortality on Northern Pike abundance. We sampled Northern Pike using experimental gill nets and angling. Gill nets were set in non-random locations, specifically to target Northern Pike. We captured and tagged a total of 58 Northern Pike during nine days of sampling. Thus far, anglers have reported six Northern Pike caught with five being harvested. These results were preliminary and dependent on completion of full year of angling effort.

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INTRODUCTION

Northern Pike *Esox lucius* were illegally introduced into Idaho's Coeur d'Alene Lake system in the early 1970s. Since that introduction, they've been illegally transferred to other northern Idaho waters, but to date their distribution in Idaho has been restricted to the five northern counties. For better or worse, Northern Pike have created some of the region's more popular fisheries. Although classified as a game fish in Idaho, management policy prohibits the intentional introduction of pike into new waters and discourages illegal introductions into other waters by removing bag limits and prohibiting catch and release tournament events. Angler exploitation, where estimated, has been high and relative densities generally low (Walrath 2013). General observations in most pike waters have suggested angler effort combined with environmental conditions limit Northern Pike abundance in Idaho waters and minimize the potential impact to native and other game fish.

Hayden Lake is located north of Hayden, Idaho in the Panhandle Region and has provided excellent fishing for multiple fish species and is popular for anglers across the region as well as non-residents. A mix of warm water species such as Largemouth Bass *Micropterus salmoides*, Black Crappie *Pomoxis nigromaculatus*, and Yellow Perch *Perca flavescens* introduced in the early 1900s are the primary angler focus (Maiolie et al. 2011). Historically, Hayden Lake provided a popular fishery for native Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, but cutthroat abundance has declined and now cutthroat are rare in the catch (Mauser 1978, Maiolie et al. 2011). Rainbow Trout *Oncorhynchus mykiss* have also been stocked in Hayden Lake since the early 1900s and have historically provided a quality fishery, but represented only a small portion of the effort and catch in recent years. More recent sportfish introductions into Hayden Lake have also provided popular fishing opportunities. Kokanee *Onchorynchus nerka* stocking has occurred in recent years and has provided a popular pelagic fishery. Smallmouth Bass *Micropterus dolomieui*, legally introduced, and Northern Pike *Esox lucius*, illegally introduced, added to littoral fisheries (Maiolie et al. 2011). Hayden Lake angling effort targeting Northern Pike is substantial and comprised approximately 20% of total effort in 2010, with catch estimated at approximately 2,000 fish (Maiolie et al. 2011).

Northern Pike in Hayden Lake are assumed to be relatively low in abundance and experience high annual angling mortality. However, quantitative estimates of these variables have not been completed. As such, limited information is available to determine what factors influence the Northern Pike population in the lake and how that population may actually be impacting the existing fish community.

OBJECTIVE

Our objective was to describe Northern Pike exploitation in Hayden Lake and provide insight on the influence of angling mortality on Northern Pike abundance.

METHODS

We sampled Northern Pike in Hayden Lake for one week in mid-May and one week in late June using experimental gill nets and angling. For each sampling event, five to eight experimental gill nets were set perpendicular to the shoreline. Sampling occurred during crepuscular hours when we anticipated Northern Pike to be most active. Nets were set for approximately one to two hours to reduce mortality. Nets were set in non-random locations specifically to target Northern Pike habitat. Net set depths ranged from 5-30 feet. Immediately upon capture, fish were measured and non-reward T-bar anchor tags (Floy Tag Inc.) were inserted diagonally forward and laterally through the dorsal pterygiophores of the anterior base of the dorsal fin. T-bar anchor tags were labeled with a specific ID number and telephone reporting number for anglers to call and report information about the fish captured. IDFG operates this toll free automated hotline and website through which anglers can report tags. Additionally IDFG distributes posters and stickers to license vendors, regional offices and sporting goods outlets that publicize the tagging efforts and explain how to report tags and what the information is used for.

We estimated an adjusted exploitation of Northern Pike using angler tag returns. Adjusted exploitation rate (μ') incorporated angler tag reporting rate, tag loss, and tag mortality, using the following formula as described by Meyer et al. (2012):

$$\mu' = \frac{\mu}{\lambda(1 - Tag_l)(1 - Tag_m)}$$

Defined terms included: μ the unadjusted exploitation rate (the number of non-reward tags recovered from fish that were harvested divided by the number of fish released with non-reward tags), λ the angler tag reporting rate, Tag_l tag loss (10.2%; Meyer et al. 2012), and Tag_m the tagging mortality rate (9.1%; McDonald 1969).

RESULTS

We tagged a total of 58 Northern Pike with eight captured via angling and 50 captured via gill nets. We set a total of 29 gillnets during the mid-May sampling period and 32 nets were set during the late June sampling period, which captured 26 and 32 Northern Pike, respectively. A total of 12 gill nets were set during dawn hours and 49 set during dusk hours. A total of seven Northern Pike were caught during dawn hours and 51 were caught during dusk hours.

One Northern Pike captured via gill net sampling was recaptured via angling during the survey. To date, 10% of tagged Northern Pike have been reported and 8% have been harvested. Meyer et al. (2012) reported an angler tag return rate of 55% for multiple species across multiple water bodies. Using this tag return and tag loss rate, along with the tagging mortality rate, exploitation was estimated at approximately 15%.

DISCUSSION

Exploitation of Northern Pike varies greatly across the species' native and non-native range. Estimates of annual exploitation in north central Minnesota lakes ranged from 4-22% and were much higher for larger fish (> 500 mm) with estimates ranging from 8-46% (Pierce and Tomcko 1995). In Coeur d'Alene Lake, Idaho, Walrath (2013) reported that exploitation was moderately high at 31%. Results from our study are preliminary but suggest that exploitation is moderate and within the expected range. The shallow northern end of Hayden Lake supports a popular ice fishery and is also the area where a large proportion of Northern Pike were caught during our sampling. Therefore, a more accurate estimate of annual exploitation will be possible after year-round angling has been completed.

To gain more information and more accurate estimates, we recommend that tagging should continue in the coming year. Sampling efficiency may be increased if completed earlier in spring following ice-out. Neumann and Willis (1995) documented that catch rates in a South

Dakota lake were highest in March and April after ice-out. Additionally, Walrath (2013) reported catch rates were 50% higher in spring (March–May) than in the summer and fall sampling periods.

MANAGEMENT RECOMMENDATIONS

1. Increase sample size of tagged fish to gain a more accurate estimate of exploitation.
2. Complete sampling earlier in the year during March and April after ice-out and target areas near spawning habitat to increase sampling efficiency.

POPULATION CHARACTERISTICS AND EXPLOITATION OF LARGEMOUTH BASS IN HAYDEN LAKE

ABSTRACT

Largemouth Bass *Micropterus salmoides* is an important sportfish throughout Idaho and select populations are managed for quality angling opportunities. Hayden Lake is one such water body where Largemouth Bass are managed under special regulations intended to achieve good catch rates of larger (≥ 406 mm) individuals. Largely due to its close proximity to several large cities, Hayden Lake supports a very popular recreational fishery, with considerable effort targeting Largemouth Bass. However, anglers have recently reported declining size structure and catch rates. We assessed Largemouth Bass population characteristics and exploitation during 2014 to identify potential factors limiting size structure. In addition, we sought to identify factors related to growth and build a quantitative framework for evaluating growth. During May–June 2014, 354 Largemouth Bass were sampled from Hayden Lake to describe population dynamics and annual angler exploitation. Angler exploitation was relatively low (4.40%), and was similar to estimates of Largemouth Bass exploitation in other north Idaho lakes. Recruitment was stable based on multiple indices, and total annual mortality was estimated to be 31.1%.Largemouth Bass require approximately 8 years to reach the 406 mm minimum-length limit, and are available to harvest for around 1–3 years depending on individual longevity. Incremental growth was highly variable among years. We found a relationship between Black Crappie *Pomoxis nigromaculatus* year-class strength and annual growth for all Largemouth Bass age classes and ages 1–4. Year-class strength of Black Crappie was inversely related to Largemouth Bass growth and explained 80% of the variability in the model for ages 1–4 of largemouth Bass. If not a causative relationship, an alternative is that an unidentified variable may act to negatively influence Black Crappie recruitment while simultaneously resulting in mortality of slow-growing Largemouth Bass. Future work may seek to better understand this relationship and identify causative factors influencing this relationship. In addition, future work related to Largemouth Bass management many benefit from evaluating the effect of site-specific factors on incremental growth.

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INTRODUCTION

Understanding the status and trends of fish population demographics (e.g., age structure, longevity) and dynamics (i.e., growth, recruitment, mortality) is central to fisheries management and conservation (Ricker 1975; Allen and Hightower 2010).Population dynamics are of particular importance to fisheries biologists because they work in concert to directly regulate the number and size of fish available in a fishery. Estimates of all three dynamic rate functions are commonly used in combination to evaluate management activities (e.g., harvest regulations, habitat enhancement) and formulate management objectives.

Recruitment is considered the most important, yet most variable, rate function regulating fish population abundance and assemblage structure (Ricker 1975; Gulland 1982). As such, understanding patterns in year-class strength and recruitment provides valuable insight on how management actions may influence various metrics (e.g., size structure, catch rates). Mortality can provide valuable insight on trends in fish populations, and knowledge of mortality rates can reflect changes in habitat, biological interactions, and exploitation (Swain et al. 2007). Collectively, recruitment and mortality act to determine the number of fish existing within a population.

While population assessments involve estimation of all three rate functions, understanding somatic growth can be particularly insightful for understanding the ecology and management of a given species. Growth is a unique population parameter because it integrates various environmental (e.g., climate; nutrient availability; physical habitat), biological (e.g., inter- and intra-specific competition), and genetic elements. Furthermore, growth is of particular importance because it indirectly regulates the other rate functions (recruitment and mortality; Quist and Spiegel 2012). All life history events (e.g., maturation; migration) and ontogenetic shifts (e.g., gape size) throughout a fish's life occur as a function of growth (Olson 1996). Therefore, growth is not only related to size structure, but also survival and reproduction, and thus critical to formulating sound fishery management plans.

Black basses *Micropterus* spp. represent a group of important freshwater sportfishes across most of their range and are commonly managed to provide quality recreational angling opportunities. Of the black basses, Largemouth Bass *Micropterus salmoides* have been introduced to many systems throughout North America because of their popularity among anglers. Although select Largemouth Bass fisheries are managed for catch-and-release angling opportunities (Cline et al. 2012), consumptive Largemouth Bass fisheries remain popular among anglers and natural resource agencies typically manage for limited harvest opportunity (Eder 1984). As such, considerable research has been dedicated to understanding the population dynamics and biology of Largemouth Bass to satisfy a diversity of values among the angling public.

A greater interest in improving Largemouth Bass angling has increased the availability of region-specific information on the species, particularly in North America (Dean et al. 1991; Beamesderfer and North 1995; Garvey et al. 2003). However, intensive management of warmwater sportfish does not have as rich of a history in the Pacific Northwest compared to other parts of the United States, making stock-specific datasets limited. Developing management plans is further complicated by the fact that population dynamics of Largemouth Bass in the Pacific Northwest are vastly different than populations where the effects of fishing regulations have been evaluated (e.g., Florida [Allen et al. 2008; Allen and Pine 2011]; Texas [Bonds et al. 2008]; Wisconsin [Schnell 2014]). These shortfalls, combined with increased interest in bass angling, have prompted fish and wildlife agencies to better understand Largemouth Bass populations in places outside of their native distribution, such as Idaho (Dillon 1990).

In Idaho, many systems are managed for quality Largemouth Bass angling. Idaho's statewide fisheries management plan describes a quality Largemouth Bass fishery as being one where anglers are likely to experience high catch rates relative to similar systems and likely to catch larger fish (i.e., > 406 mm) in waters with special regulations (IDFG 2013). Currently, the most restrictive quality Largemouth Bass fisheries in Idaho are managed to provide at least limited harvest opportunity with no systems being managed exclusively as catch-and-release fisheries.

Hayden Lake in the Idaho Panhandle is managed as a quality Largemouth Bass fishery and is one of the Panhandle Region's most popular fisheries for the species. The fishery supports tournament angling each year targeting Largemouth Bass among other species. Despite its regional importance, relatively little is known about exploitation patterns, population characteristics, and potential factors influencing Largemouth Bass in Hayden Lake. The Largemouth Bass population is managed under special regulations (2 fish daily bag limit; none under 406 mm) and has historically produced some of the finest Largemouth Bass fishing in the Panhandle Region. Previous creel surveys have shown that Largemouth Bass angling comprises around 10% of the total annual angling effort in Hayden Lake (Davis et al. 1995). While catch rates of Largemouth Bass have typically been good, exploitation has remained relatively low (~ 12%), similar to other Panhandle Region lakes (Liter et al. 2003). However, anglers have noted declines in size structure and catch rates of quality Largemouth Bass in recent years. Therefore, this study was conducted to assess the Largemouth Bass population in Hayden Lake to estimate exploitation, population characteristics, and growth patterns. In addition, a major focus was to develop a quantitative framework incorporating site-specific and fish assemblage variables that can be used to predict growth in other systems.

OBJECTIVES

1. Estimate angler exploitation of Largemouth Bass in Hayden Lake.
2. Estimate dynamic rate functions (i.e., growth, recruitment, mortality) and population characteristics (i.e., relative abundance, size structure, age structure) of Largemouth Bass in Hayden Lake.
3. Evaluate the effect of biotic and environmental factors on growth of Largemouth Bass.
4. Evaluate the efficacy of current regulations and alternative regulation scenarios for improving Largemouth Bass angling opportunity in Hayden Lake.

STUDY AREA

Hayden Lake is a natural oligotrophic water body located in Kootenai County, Idaho near the city of Hayden Lake, Idaho (Figure 20).The lake is approximately 1,568 ha in total surface area and has a maximum depth of 54 m (Bellatty 1990). Hayden Lake has around 43 km of shoreline, of which 85% has been residentially or agriculturally developed (Wersal et al. 2010). The lake supports a mixed fishery for both warmwater and coldwater fish species including Largemouth Bass, Smallmouth Bass *M. dolomieu*, Yellow Perch *Perca flavescens*, Black Crappie *Pomoxis nigromaculatus*, Northern Pike *Esox lucius*, kokanee *Oncorhynchus nerka*, Westslope Cutthroat Trout *O. clarki lewisi*, and Rainbow Trout *O. mykiss* (Ryan et al. 2014). Hatchery Rainbow Trout and kokanee are typically stocked annually to supplement the coldwater component of the fishery. In fact, early-spawning kokanee stocks have been very successful in Hayden Lake and have become a very popular fishery.

METHODS

Fish Sampling and Hard Structure Processing

Largemouth Bass were sampled from Hayden Lake during May–June 2014 when Largemouth Bass are known to occupy shallow water habitat (Winter 1977; Schnell 2014). The shoreline of each lake was measured and segmented into 400-m long sampling units using ArcGIS Version 10.1 (Esri, Redlands, California, USA). The upper and lower terminus of each segment was georeferenced and a simple random sampling design was used to allocate sampling effort among segments. Nighttime boat-mounted electrofishing was used to capture Largemouth Bass. Previous studies have shown that electrofishing is an effective sampling technique used to sample Largemouth Bass and is commonly used by natural resource agencies (Hall 1986; Ebbers 1987; Hill and Willis 1994; Bonar et al. 2009). Electrofishing equipment consisted of a Smith-Root model VVP-15b electrofisher (Smith-Root, Inc., Vancouver, Washington, USA). Electrofishing output was standardized to 3,000 W based on ambient water conductivity and temperature (Miranda 2009). Two netters collected fish from the bow of the boat during sampling. Electrofishing effort consisted of a single, 600-s pass allocated to each segment proceeding in a clockwise direction around the lake. Upon completion of each sampling segment, each Largemouth Bass was measured to the nearest millimeter (total length).The first and second dorsal spines were removed from 10 individuals per 1-cm length group for each lake, if present. Largemouth Bass ≥ 406 mm were tagged using a non-reward FD-94 T-bar anchor tags (76 mm; Floy Tag Inc., Seattle, Washington, USA) to evaluate angler exploitation. Each tag was uniquely-numbered and inserted near the posterior end of the dorsal fin of each Largemouth Bass. All tags also possessed the telephone number for the IDFG's "Tag! You're It!" reporting hotline. Exploitation of Largemouth Bass was estimated using the non-reward tag methods described by Meyer et al. (2012) and included estimates of tag loss and tagging mortality.

Dorsal spines were allowed to air dry and subsequently mounted in epoxy using 2-mL microcentrifuge tubes following Koch and Quist (2007). Cross sections (0.9-mm thick) were cut near the base of each dorsal spine just distal to the articulating process using an Isomet low-speed saw (Buehler Inc., Lake Bluff, Illinois, USA). Resulting dorsal spine cross-sections were viewed using a dissecting microscope with transmitted light and an image analysis system (Image ProPlus; Media Cybernetics, Silver Springs, Maryland, USA).Annuli were enumerated on all structures independently by two readers during a mutual examination. Knowledge of biological information for each fish was unknown during the age estimation process to avoid bias. Distances between annuli were measured on each dorsal spine cross-section to evaluate incremental growth. In addition, confidence ratings were assigned to each dorsal spine as a subjective measure of the readability of individual structures. We specifically followed the rating criteria from Spiegel et al. (2010) and Koch et al. (2008) where confidence ratings were integers between 0 and 3. A confidence rating of 0 corresponded to no confidence, and a rating of 3 corresponded to complete confidence in the reader's age estimate. Age estimate confidence ratings allowed the data to be truncated to ensure that only the highest confidence dorsal spines were used in subsequent analyses.

Data analysis

Largemouth Bass population metrics and angler exploitation

Catch-per-unit-effort (CPUE) was estimated as the number of fish sampled per electrofishing segment (i.e., each 600- pass).Exploitation (μ) was estimated as the number of fish harvested by anglers (obtained from tag return information) divided by the number of fish tagged. We assumed a 39% reporting rate and 13% tag-loss based on work conducted by Meyer et al. (2012).

Proportional size distribution (PSD) was used to summarize length-frequency distributions (Gablehouse 1984; Neumann et al. 2012) and describe size structure. Proportional size distribution was calculated as

$$PSD = (a / b) \times 100,$$

where a is the number of fish greater than or equal to the minimum quality length and b is the number of fish greater than or equal to the minimum stock length (Neumann et al. 2012). Size structure was further evaluated using PSDs for other length categories (i.e., preferred, memorable, trophy) and based on current harvest regulations (i.e., 406 mm; minimum-length limit). Minimum total lengths for each category are provided by Neumann et al. (2012).

Age structure of Largemouth Bass was estimated with an age-length key (Isermann and Knight 2005; Quist et al. 2012). Total annual mortality (A) was estimated using a weighted catch curve (Miranda and Bettoli 2007). Only age-2 and older Largemouth Bass appeared to be fully-recruited to the sampling gear, so A was only estimated for age-2 and older fish. Age structure information was used to describe patterns in recruitment; and those patterns were described using several techniques. Recruitment was first indexed using the residual technique described by Maceina (1997) where residual estimates derived from a catch curve regression represent relative year-class strength (i.e., positive residuals = strong year-classes; negative residuals = weak year-classes). Secondly, recruitment was indexed using the recruitment variability index (RVI; Guy and Willis 1995) and was calculated as

$$RVI = [S_N / (N_M + N_P)] - N_M / N_P,$$

where S_N is the summation of the cumulative relative frequencies across year-classes included in the sample, N_M is the number of year-classes missing from the sample (year-classes beyond the oldest year-class in the sample are excluded), and N_P is the number of year-classes present in the sample (N_P must be greater than N_M). Recruitment variability index values vary from -1 to 1, with values close to 1 representing stable recruitment. Development of the RVI was partially based on catch-curve analysis because fish populations with stable recruitment will exhibit a steady decline in numbers as age increases. Lastly, the recruitment coefficient of determination (RCD; Isermann et al. 2002) was also used to explain stability in recruitment. The RCD is simply the coefficient of determination (R^2) value that results from a catch-curve regression. Indices of recruitment are often useful for comparing among water bodies and provide a general idea of recruitment stability over multiple years.

Mean back-calculated lengths at age were estimated using the Dahl-Lea direct proportion method (Quist et al. 2012)

$$L_i = L_c \times (S_i / S_c),$$

where L_i is the length at annulus i, L_c is the length at capture, S_i is the dorsal spine radius at annulus i, and S_c is the fin ray radius at capture. Growth was summarized by fitting a von Bertalanffy growth model (von Bertalanffy 1938)

$$L_t = L_\infty \left[1 - e^{-K(t - t_0)}\right]$$

where L_t is the mean length at age of capture, L_∞ is the theoretical maximum length, K is the growth coefficient, and t_0 is the theoretical age when length equals 0 mm. Models were fit with nonlinear regression techniques using Program R (nlstools package; R Development Core Team 2012; Seber and Wild 2006). Estimates of incremental growth were used to provide insight on current regulations.

Growth modeling

Hard parts like dorsal spines contain information on multiple years spanning the entire life of the fish, keeping a record of past growth. As such, a one-time sample using hard parts can provide insight on multiple years when long-term growth data are unavailable. Fish growth is partitioned into year effects based on external conditions and age (size) effects. Growth is highly influenced by fish size, and size dependently increases as a function of age making it difficult to evaluate variability in growth size and other (environmental, biological interactions, etc.) effects. To address this issue, a repeated-measures mixed-effects model was used to partition the effects of age and year on incremental growth of Largemouth Bass (Weisberg et al. 2010)

$$y_{cka} = l_a + h_{c+a-1} + F_{ck} + e_{cka},$$

where y_{cka} is the a^{th} annular increment for the k^{th} fish from the c^{th} year class, l_a is the annular increment for a fish in the a^{th} year of life, h_{c+a-1} is the environmental effect for year $l = c + a - 1$ which is the year in which a fish in year class c was of age a, f_{ck} is the effect of fish k in the c^{th} year class, and e_{cka} is the model error. Age was treated as a fixed effect and year was treated as a random effect (i.e., each year was considered a random draw from the sampling distribution) in the model and repeated measures were taken from each Largemouth Bass. Because a major focus of this project was to evaluate which age-classes exhibited growth relationships, the model was fitted to two age groups. The model was first fit using all age-classes (“all ages”) and then using only age-class 1–4. The benefit of this approach is that all individuals are retained in each model, and only ages are removed. An autoregressive covariance structure was used and models were fit using Program R (lme4 package; R Development Core Team 2012).

We focused on Black Crappie year-class strength, total annual stocking of *Salmonidae* spp. (i.e., kokanee, Rainbow Trout) fry and fingerlings, mean minimum annual temperature, temperature during the growing season, total annual precipitation, and precipitation during the growing season as covariates influencing growth and recruitment variability of Largemouth Bass. Black Crappie year-class strength was indexed using the residual technique from a weighted catch curve regression. Black Crappies were sampled and age was estimated as part of another study according to standard methods (see Chapter 8; Isermann et al. 2010). Historical climate data from 2003 to 2014 were obtained from the National Oceanic and Atmospheric Administration (NOAA) weather station near Hayden, ID. Mean air temperature and total precipitation were estimated for the growing season (April 1–September 30) during each year. Mean minimum air temperature and total annual precipitation were estimated for each calendar year (January 1–December 31). Biological and environmental variables were used as independent explanatory variables in subsequent modelling exercises.

An information theoretic approach was used to select among competing linear multiple-regression models explaining variability in growth (Burnham and Anderson 2002).Twelve *a priori* candidate models were developed to predict annual incremental growth based on our hypotheses about Largemouth Bass growth. Annual growth increments were treated as the dependent response variable in all multiple-regression models. Akaike's information criterion corrected for small sample size (AIC_c) bias was used to rank and assess the relative importance of each candidate model, where the most parsimonious model is the one with the lowest AIC_c value. Akaike weights (w_i) were used to assess the relative plausibility of each candidate model. Information theory only ranks models, but all models may be poor indicators of growth; therefore, the coefficient of determination (R^2) was used as a measure of model fit.

Multicolinearity among explanatory variables was assessed prior to creating candidate models. Pearson's product-moment correlation coefficient was used to evaluate the correlation among all possible pairs of covariates. When two covariates were significantly correlated (Pearson's $r \geq |0.70|$; $P \leq 0.05$), the variable with the most logical relevance of a significantly correlated pair was retained for further analysis. For instance, Black Crappie year-class strength and salmonid fry stocking were significantly correlated ($r = 0.94$; $P = 0.002$); therefore, we retained Black Crappie year-class strength in the candidate model suite and instead used total salmonid stocking (includes fingerlings; not significantly correlated) to represent variability that may be explained by the correlated covariate.

RESULTS

A total of 354 Largemouth Bass was sampled from Hayden Lake during this study. Anglers had reported four tags as of December 31, 2014. Of those, two were harvested and two were released. We estimated a corrected annual exploitation rate of 4.40%.Relative abundance was highly variable (mean CPUE = 5.88 fish/segment; SE = 1.77) and varied from 0–24 fish/segment. The highest relative abundance was observed at the north end of the system where better Largemouth Bass habitat was available. Very few Largemouth Bass were sampled in the southern portion of the system. Mean total length of Largemouth Bass was 267.1 mm and total length varied from 74–494 mm. Proportional size distribution and RSD-406 were 45 and 15, respectively, indicating a relatively poor size structure with only 15.0% of stock-length fish meeting or exceeded the minimum length limit (Figure 21).

Age structure was used to examine population mortality and recruitment. Age estimates varied from 1–11 years (Figure 22).Only age-2 and older Largemouth Bass appeared to be recruited to the sampling gear, so a catch-curve regression was fitted to ages 2–11.We estimated a 31.1% total annual mortality rate and an instantaneous mortality rate of 0.37 (Figure 23). Recruitment patterns showed some slight variability among years (Figure 24), but overall recruitment has been very consistent (RVI = 0.90; RCD = 0.83; Figure 23). No missing year-classes or weak year-classes were observed, thus contributing to the stable recruitment estimates.

Mean back-calculated length-at-age was estimated for 302 Largemouth bass. Largemouth Bass reached preferred length (304 mm) in 4–5 years and quality length (380 mm) in 6–7 years (Figure 25). Largemouth Bass in Hayden Lake require around 8 years to reach the 406 mm minimum length limit, meaning that long-lived individuals may be available for harvest for a maximum of 3–4 years. Growth rates were highest for ages 1–4, and appeared to slow thereafter (Figure 25).

Incremental growth provided a great deal of insight on age-specific patterns and factors related to growth at different life history stages. Annual growth increments declined as a function of age for all individuals exceeding age-4. When compared using all age-classes, incremental growth was variable among years (Figure 26). Significant differences of up to 30 mm between the most disparate estimates were observed. This pattern was even more evident for incremental growth of ages 1–4 (Figure 27).

Biological and environmental variables (Table 7) showed strong relationships with incremental growth. The best model predicting annual growth of Largemouth Bass among both groups (i.e., all ages and ages 1–4) was the one incorporating only Black Crappie year-class strength, for which we observed a negative relationship (Table 8). The second best models, although not sufficiently parsimonious, were annual stocking rate (all ages; positive relationship) and mean minimum annual temperature (all ages; positive relationship). Black Crappie year-class strength explained 80% of the variation in growth for ages 1–4 and 77% of the variation in growth for all ages of Largemouth Bass (Table 8). Although models incorporating environmental variables and total annual salmonid stocking did not carry as much weight as Black Crappie year-class strength, they typically had good predictive power.

DISCUSSION

Largemouth Bass remain the most popular resident sportfish species in Idaho following trout species (IDFG 2013). Largemouth Bass can be found in all seven of IDFG's regions where they support popular fisheries, both consumptive and non-consumptive. Hayden Lake has produced some of the finest Largemouth Bass angling in North Idaho and is a tremendously popular location due to its close proximity to several major cities. In addition, Hayden Lake supports numerous tournaments each year, several of which target Largemouth Bass. For these reasons, Hayden Lake is a high management priority in northern Idaho and will continue to be.

Our results confirm anecdotal evidence that size structure of Largemouth Bass in Hayden Lake is indeed poor relative to the goals for a water body managed under a quality bass rules. However, the current size structure is not likely a result of harvest of quality size individuals. We found that annual exploitation was relatively low (4.40%) and therefore would likely be a minimal contribution to total annual mortality. However, the relationship between harvest-related mortality and size structure may not be best understood by considering annual exploitation alone. Rather, understanding how the cumulative effect of exploitation over multiple years acts to determine the number of quality-size individuals in population may be more telling. While cumulative exploitation is not necessarily a limiting factor for short-lived species that are available to harvest for 1–2 years (e.g., kokanee), long-lived species may exhibit a greater response. Little research is available regarding the effect of cumulative exploitation on size structure, particularly because it requires long-term information on recruitment as well. We surmise, however, that this may contribute to depressed size structure among populations of long-lived species that experience very conservative harvest. Therefore, estimating annual exploitation alone may not provide a complete understanding of how harvest structures fish populations like Largemouth Bass in the Pacific Northwest.

Our observations remain consistent with other studies in the Panhandle Region that have assessed Largemouth Bass population dynamics (Hardy 2008; Fredericks and Horner 1995). Largemouth Bass are slow-growing in the Pacific Northwest (Beamesderfer and North 1995; Rieman 1987; Dillon 1990) and Hayden Lake is no exception. On average, Largemouth Bass require 8 years to reach the minimum length limit and recruit to the harvestable portion of the fishery. We observed a maximum age of 11 years in Hayden Lake, and typical longevity for wild bass across their range is around 12 years. As such, we are confident that we were able to reasonably estimate maximum age of Largemouth Bass in Hayden Lake. Based on our estimates of longevity, individuals that surpassed the minimum length limit are typically available to harvest for 1–3 years.

Like mortality, quantifying recruitment and understanding recruitment variability is critical to understanding how fish populations change and how they ought to be managed. We observed stable recruitment according to all metrics we measured during this study. Although recruitment varied among years, the variability appeared to be minimal and year-class failure was not observed. In fact, many of the “poor” year-classes observed remained within the range of variability considered stable according to other studies (Jackson and Noble 2000; Gunter and Anderson 1985). It is therefore unlikely that chronic year-class failure has significantly contributed to the poor PSD estimates and lack of harvestable individuals in the population. Certainly, long-term data on the Hayden Lake Largemouth Bass stock would provide a better means for assessing recruitment dynamics, but these sorts of data are not available for Hayden Lake. We acknowledge that the available techniques for indexing recruitment variability may not have the resolution needed to sufficiently compare the relative performance of age-classes comprising the preferred- and quality-length groups. Despite the shortcomings of indexing recruitment via the RVI and RCD, these techniques have been previously evaluated (Quist 2007) and are common metrics used by fisheries biologists to assess recruitment with a one-time sample and to compare recruitment among populations.

Incremental growth provided some of the most important information, not only for Largemouth Bass management, but also for management of other species in Hayden Lake. Our modeling suggests that environmental variables and salmonid stocking indeed are good predictors of Largemouth Bass growth in Hayden Lake. However, none of the models incorporating these covariates were as parsimonious as the best model, which contained only Black Crappie year-class strength for both age groups. The relationship was negative for both groups, but the model showed that the effect of strong Black Crappie year-classes had better predictive power for age 1–4 Largemouth Bass.

Previous studies that have examined Largemouth Bass growth have focused primarily on abiotic factors (e.g., temperature; Dillon 1990), and those that have evaluated biotic factors have focused on prey availability (Gunter and Anderson 1985). Cumulatively, environmental conditions and prey abundance are known to effect growth of Largemouth Bass (Niimi and Beamish 1974; Gunter and Anderson 1985; McCauley and Kilgour 2011); however, very few studies have examined relationships with abundance of interspecific competitors. In fact, previous research in Idaho has also demonstrated that Largemouth Bass growth is most closely related to temperature (Dillon 1990). While our own results support temperature as a predictor of Largemouth Bass growth, it was not as well supported as biological factors.

Both Black Crappies and Largemouth Bass are common in warmwater fish assemblages around the state of Idaho, and many warmwater assemblages possess both species. Most Black Crappie fisheries are managed as yield fisheries and few are managed under quality regulations. On the contrary, Largemouth Bass populations are commonly managed using restrictive harvest regulations to provide quality angling in many systems around Idaho. Hayden Lake is unique in that it is managed to provide quality angling for both Black Crappie (6 fish daily bag limit; none under 10") and Largemouth Bass. Limited harvest of adult Black Crappie likely allows more individuals to reach sexual maturity, become highly fecund, and have more successful recruitment. Black Crappie are known to exhibit highly variable recruitment and, because crappie fisheries are harvest oriented, year-class strength may be improved by protecting the sexually-mature portion of the population. Although, competitive interactions between Black Crappie and Largemouth Bass are not well understood, our results show that growth of Largemouth Bass may be influenced by strong year-classes of Black Crappie. The effect on growth is particularly influential on young Largemouth Bass. This is concerning because the early life stages are critical for Largemouth Bass growth (Olson 1996; Niimi and Beamish 1974). Somatic growth is highest during the early life stages of Largemouth Bass in Hayden Lake, and somatic growth accrued during the first four years of life has implications for what size the individual is when ontogenetic shifts occur and when growth rates will slow due to gonadal development. As such, slow growth during the early life stages may have long lasting effects on the size structure of a population. In light of current management of Largemouth Bass in Hayden Lake, this may imply that some individuals do not reach desired PSDs or length limits due to reduced growth over multiple years.

MANAGEMENT RECOMMENDATIONS

1. Evaluate exploitation again in 2015 to assess the potential effects of cumulative exploitation.

2. Consider more restrictive length limit regulations to protect fish ≥16". Monitor size structure response to regulation change.

3. Evaluate other relationships between growth of Largemouth Bass and assemblage and population characteristics.

4. Evaluate whether relationships observed in Hayden Lake occur in other lentic system in the Panhandle Region.

Table 7. Abbreviation and description of covariates included in multiple-regression models developed to predict growth and year-class strength of Largemouth Bass in Hayden Lake, Idaho (2014).

Covariate	Abbreviation	Description
Black Crappie year-class strength	BCR	Residual estimates of Black Crappie year-class strength
Salmonid stocking	Stocking	Total Kokanee and Rainbow Trout stocked (fry and fingerling)
Mean minimum annual temperature	Min temp.	Mean minimum temperature, calculated monthly (°C)
Total annual precipitation	Precip.	Total precipitation during 1 January–31 December (mm)
Precipitation during growing season	GS precip.	Total precipitation during 1 April–30 September (mm)
Temperature during growing season	GS temp.	Mean temperature during 1 April–30 September (°C)

Table 8. Multiple-regression models and derived parameter estimates predicting growth of Largemouth Bass in Hayden Lake, Idaho. Number of model parameters (K), Akaike's information criterion corrected for small sample size (AIC_c), change in AIC_c value (ΔAIC_c), and AIC_c weights (w_i) were used to select the top model from a set of a priori candidate models. The coefficient of determination (R^2) is provided as a measure of goodness-of-fit. The top model for each subset is indicated by bold text. A complete description of covariates can be found in Table 1.

Model	K	AIC_c	ΔAIC_c	w_i	R^2
		Ages 1–4			
-BCR	**3**	**56.40**	**0.00**	**0.76**	**0.80**
+Min temp	3	59.91	3.51	0.13	0.65
+Stocking	3	60.94	4.55	0.08	0.60
+Precip	3	64.95	5.56	0.01	0.28
+GS precip	3	66.66	10.26	0.00	0.08
+GS temp	3	66.73	10.33	0.00	0.08
-BCR, +GS temp	4	68.25	11.85	0.00	0.84
-BCR, +Precip	4	68.89	12.49	0.00	0.82
-BCR, +GS precip	4	70.27	13.87	0.00	0.79
+Precip, +Min temp	4	70.60	14.20	0.00	0.78
+GS precip, +GS temp	4	77.09	20.69	0.00	0.45
+Stocking, +GS precip, +GS temp	5	113.59	57.20	0.00	0.74
		All ages			
-BCR	**3**	**55.19**	**0.00**	**0.71**	**0.77**
+Stocking	3	57.67	2.48	0.20	0.67
+Min temp	3	60.44	5.25	0.05	0.52
+Precip	3	62.21	7.02	0.02	0.38
+GS precip	3	64.97	9.78	0.01	0.08
+GS temp	3	65.16	9.97	0.00	0.05
-BCR, +Precip	4	65.81	10.63	0.00	0.86
-BCR, +GS temp	4	68.05	12.86	0.00	0.81
-BCR, +GS precip	4	69.01	13.83	0.00	0.78
+Precip, +Min temp	4	70.25	15.06	0.00	0.73
+GS precip, +GS temp	4	76.50	21.31	0.00	0.35
+Stocking, +GS precip, +GS temp	5	111.70	56.51	0.00	0.75

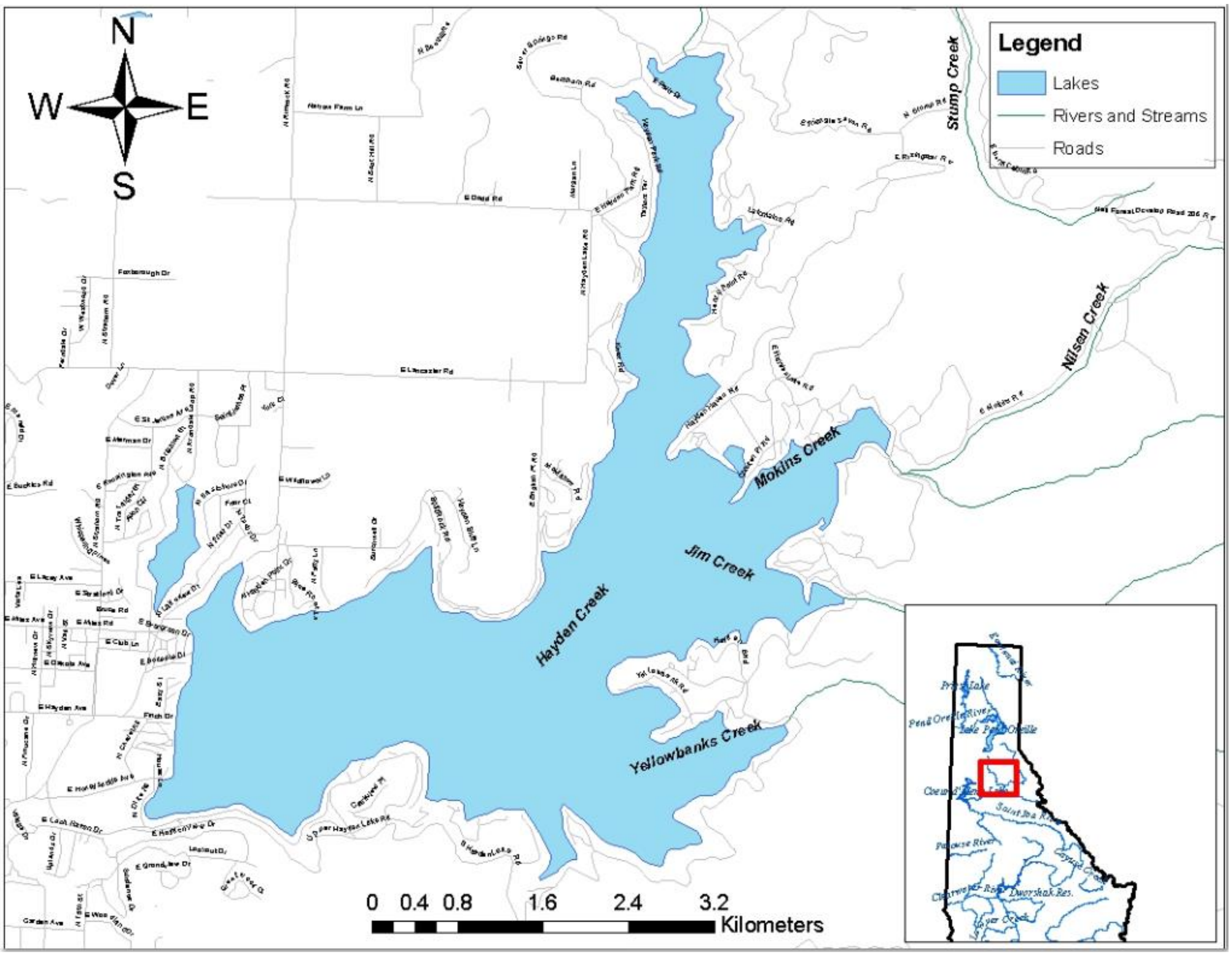

Figure 20. Location of Hayden Lake, Idaho.

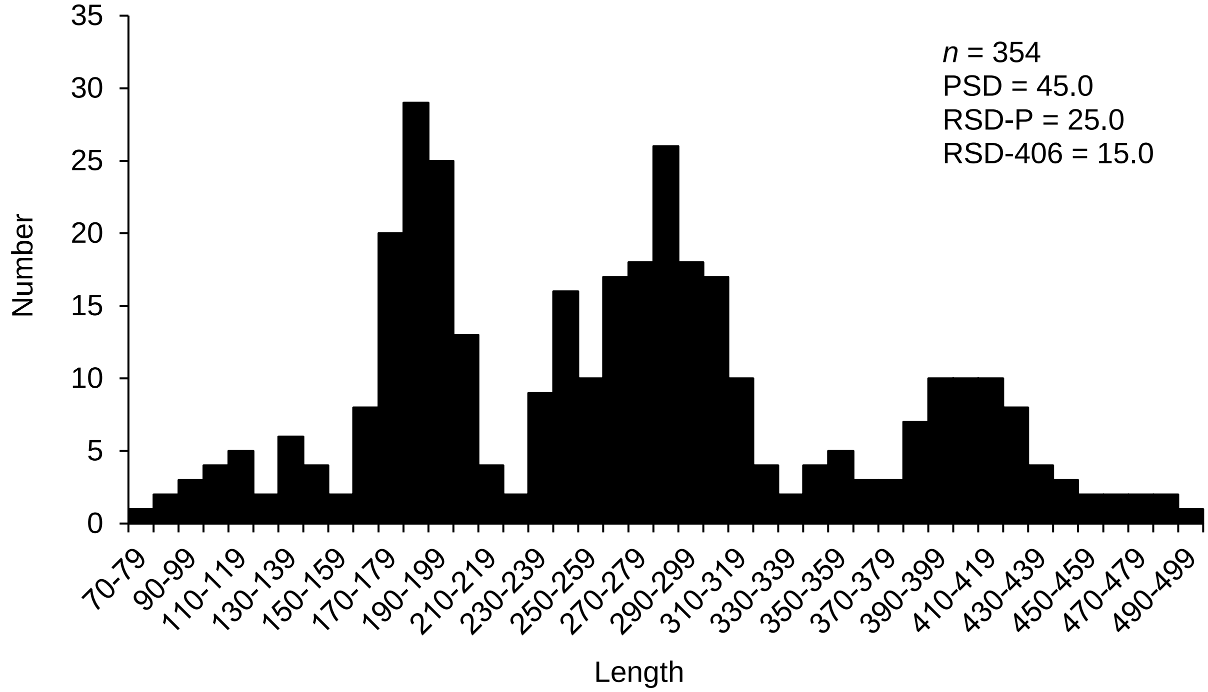

Figure 21. Length-frequency distribution and PSD values for Largemouth Bass sampled from Hayden Lake, Idaho (2014).

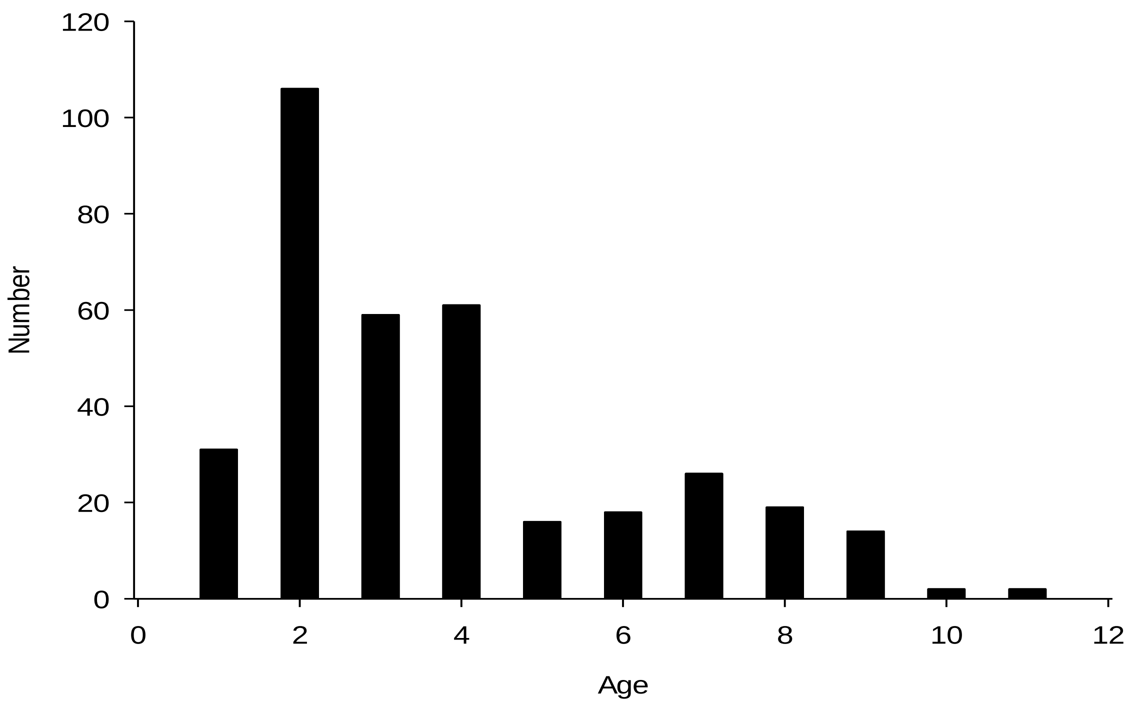

Figure 22. Age distribution of Largemouth Bass sampled from Hayden Lake, Idaho (2014).

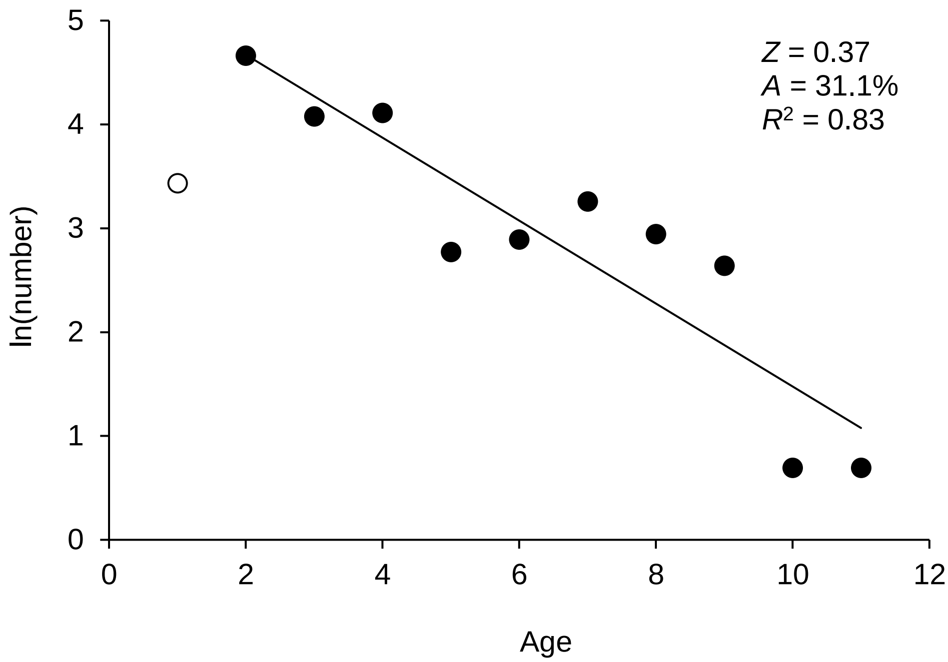

Figure 23. Weighted catch-curve regression estimating mortality and recruitment variability for Largemouth Bass sampled from Hayden Lake, Idaho (2014). Closed circles represent age-classes for which the regression model was fitted. Open circles represent age classes that were not fully-recruited to the gear, and not included the model.

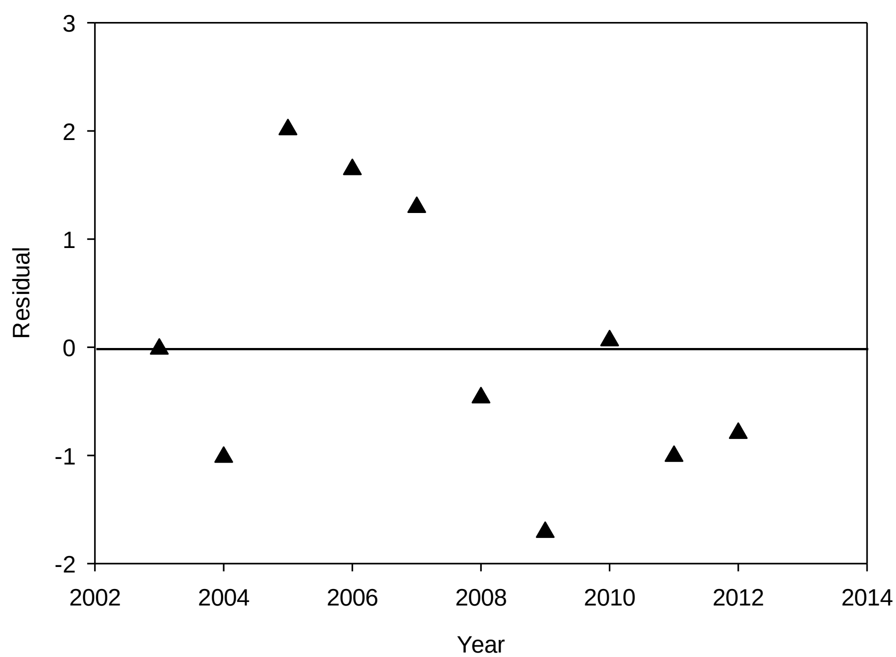

Figure 24. Estimates of Studentized residuals from a catch-curve regression for Largemouth Bass sampled from Hayden Lake, Idaho (2014). Positive residuals represent strong year-classes and negative residuals represent weak year-classes.

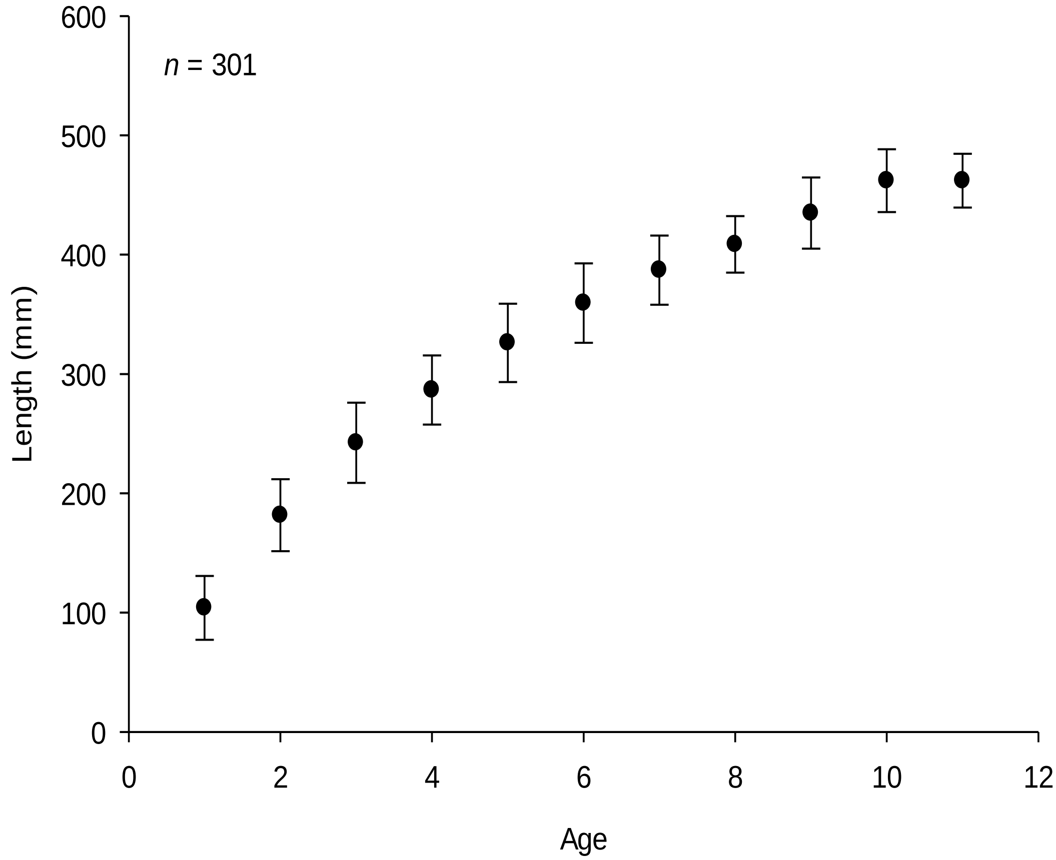

Figure 25. Mean back-calculated length-at-age for Largemouth Bass sampled from Hayden Lake (2014). Error bars represent the standard deviation of the mean.

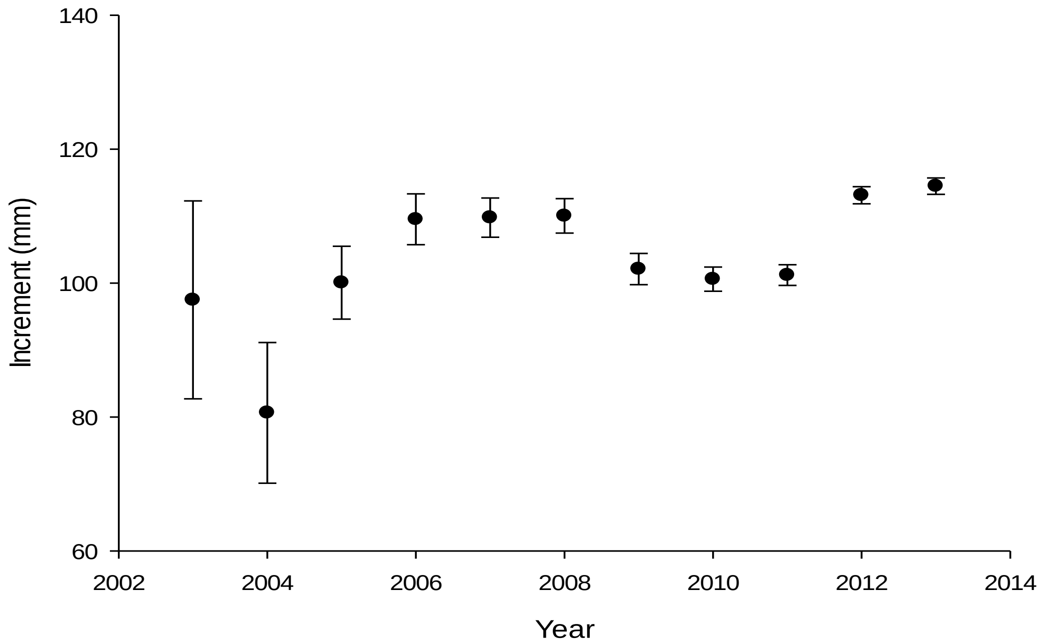

Figure 26. Annual growth increment estimates for all age-classes of Largemouth Bass sampled from Hayden Lake, Idaho (2014). Error bars represent one standard error of the mean.

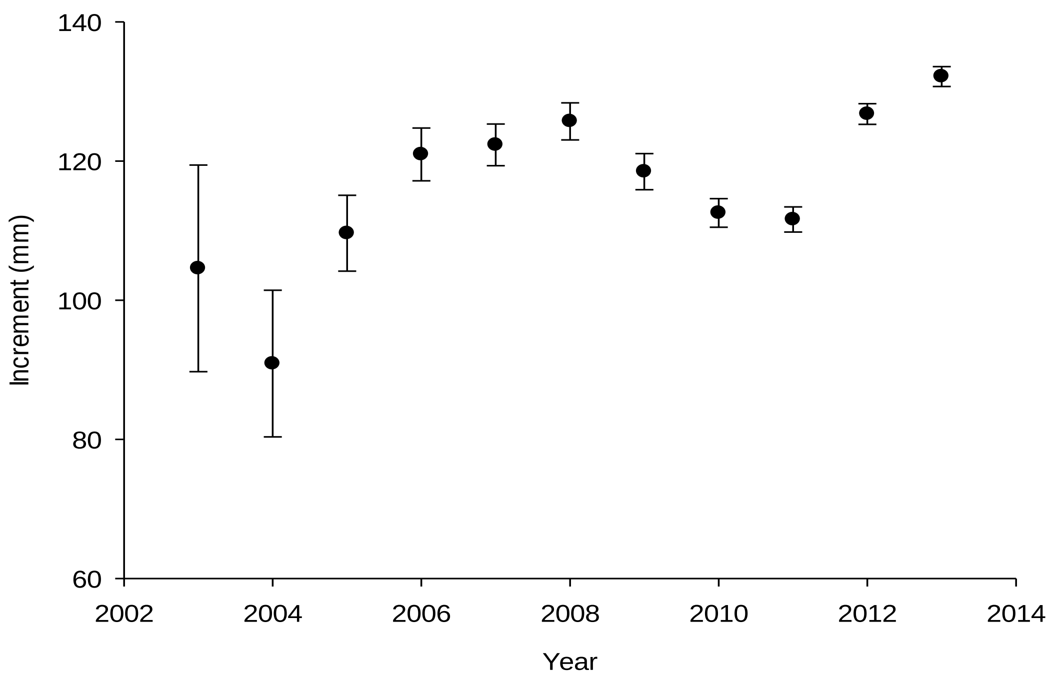

Figure 27. Annual growth increment estimates for all ages 1–4 Largemouth Bass sampled from Hayden Lake, Idaho (2014). Error bars represent one standard error of the mean.

UPPER PRIEST LAKE LAKE TROUT CONTROL

ABSTRACT

Upper Priest Lake is currently managed for the protection of native species. In support of this objective, removal of non-native Lake Trout has occurred since 1998. In 2014, gill nets were used to remove 2,494 Lake Trout during a one-week period from May 27 to June 2, 2014. Average daily catch rate from standard mesh sizes was 21.5 fish/box (± 6.9, 80% C.I.), an increase from 2013. Catch rate generally declined as cumulative Lake Trout catch increased, suggesting we depleted the initial population over the seven-day effort. We estimated Lake Trout adjusted exploitation from Upper Priest Lake removal efforts using recapture rates of tagged fish, which ranged between 21% and 31%. Lake Trout length ranged from 191 to 877 mm (Figure 31). In general, fish length increased with increased gill net mesh size. Bull Trout catch rate (0.26/box) was close to average for the last eight year period (0.21 Bull Trout per box). Evaluation of exploitation rates and depletion trends suggested the estimates reported in past years may have overestimated the percentage of the population removed each year. Alternative methods of evaluating removal efforts, such as the use of catch rates from standardized gear, may be more effective. Our observed catch rates in standard gill net catch rate comparisons since 2010 suggested abundance of Lake Trout recruited to the gear has not significantly changed despite continued annual efforts to reduce abundance. However, Bull Trout catch rate trends suggested their abundance in Upper Priest Lake has increased since 2007 in concert with continued Lake Trout removal efforts.

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Regional Fishery Biologist

INTRODUCTION

Historically, native Bull Trout *Salvelinus confluentus* provided a trophy fishery in Upper Priest Lake with an annual catch of 1,800 fish in the 1950s (Bjorn 1957). Bull Trout harvest was eliminated in 1984, but no positive response in the population resulted (Mauser et al. 1988). The Bull Trout population in Upper Priest Lake was considered severely depressed while the population in Priest Lake was considered functionally extinct in (DuPont et al. 2007).

Native Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* were also historically abundant in Priest Lake and Upper Priest Lakes with 30 fish limits common in the 1940s (Mauser et al. 1988). Overharvest, interspecific competition, predation and degradation of spawning habitat were all believed to contribute to the decline of Cutthroat Trout in Priest Lake. Cutthroat Trout were closed to harvest in 1988.

In Upper Priest Lake, the Lake Trout *S. namaycush* population has grown rapidly during the past 30 years. Lake Trout were not known to be present in Upper Priest Lake until the mid-1980s at which time they were thought to have begun migrating from Priest Lake (Mauser 1986). In 1998, the Upper Priest Lake Lake Trout population was estimated at 859 fish (Fredericks and Vernard 2001). Non-native Lake Trout are often thought to suppress other native and non-native species through predation and/or competition where introduced (Donald and Alger 1993, Fredenberg 2002, Hansen et al. 2008).

In an effort to reduce the potential impacts of Lake Trout on Bull Trout and Westslope Cutthroat Trout populations, the Idaho Department of Fish and Game (IDFG) has gill netted annually since 1998 to remove Lake Trout and reduce their abundance in Upper Priest Lake. Management efforts have collected between 150 and 5,000 Lake Trout annually from Upper Priest Lake (Fredericks et al. 2013). In 2014, we continued Lake Trout reduction efforts in Upper Priest Lake using gill nets.

OBJECTIVE

Maintain native fish populations (Bull Trout, Cutthroat Trout, and Pygmy Whitefish *Coregonus coulteri*) in Upper Priest Lake by reducing Lake Trout abundance.

STUDY SITE

Upper Priest Lake is located approximately 21 kilometers (km) south of the Idaho-British Columbia boarder in the northwest corner of the Idaho Panhandle. It is a glacial lake that has roughly 13 km of shoreline, a surface area of 566 hectares (ha), a maximum depth of approximately 31 meters (m) and a maximum temperature of approximately 21 ˚C. The lake is bathtub shaped with steep walls and a flat bottom. Upper Priest and Priest lakes are held at 743 m elevation from the end of spring run off until mid-October using a small damn located at the outlet of Priest Lake. Upper Priest Lake is connected to Priest Lake by a channel known as the Thorofare. The Thorofare is roughly 3.2 km long, 70 m wide and 1.5-3 m deep at summer pool. At low pool water depth in the Thorofare outlet is < 0.15 m blocking most boat traffic.

METHODS

Lake Trout Removal from Upper Priest Lake

We completed the 2014 Upper Priest Lake Lake Trout removal effort between May 27 and June 2, 2014. Hickey Brothers Research LLC was contracted to provide equipment and labor for completion of the netting project. An 11 m commercial gill net boat was used to complete sampling efforts. Funding for completion of the lake trout removal effort was provided by the United States Fish and Wildlife Service (USFWS) and the Kalispell Tribe.

We used monofilament sinking gill nets to capture and remove Lake Trout from Upper Priest Lake. Individual gill net dimensions were 91 m by 2.7 m. Nets were tied together end to end to create a single long net string. Each net string or combination of boxes contained a standardized range of mesh sizes including 45 mm, 51 mm, 64 mm, 76 mm, 89 mm, 102 mm, 114 mm, and 127 mm stretched mesh (Table 9). Effort units were measured as net boxes. Each box of net was equivalent to approximately 273 m or three 91 m nets. Daily effort was split between morning and afternoon sets each day. The combined effort per day was 30 boxes of gill net. A total of 180 boxes of gill net were placed over seven days. Both morning and afternoon sets were made on each day except the initial and final netting dates during which only one set was made on each date. The combined total effort for the initial and final day of netting was 30 boxes. Typically 18 boxes of net were set in the AM and 12 boxes of net were set in the PM. The combined effort by mesh size was consistent within AM and PM sets respectively, for all sets except on the initial and final days of netting. On the initial day of netting 18 boxes of net were set in the PM. On the final day of netting 12 boxes of net were set in the AM. The time between net placement and initiating net lifting ranged between two to five hours for all sets. Gill nets were set throughout Upper Priest Lake over the course of the sampling period at depths ranging from 10 to 31 m. Placement of nets in and around the primary inlets and outlet of Upper Priest Lake was avoided to reduce by-catch of Bull Trout and Westslope Cutthroat Trout.

We estimated measures of both relative and absolute abundance from gill net catches. Relative abundance of Lake Trout in Upper Priest Lake was measured as average daily catch per unit of effort (CPUE) or fish per net box per day for catch associated with 51-, 64-, and 76-mm mesh sizes. These mesh sizes were selected as standards because they represented the longest time series of mesh sizes fished during Upper Priest Lake removal efforts. We compared these standardized catch rates to prior years to evaluate Lake Trout population trends in Upper Priest Lake. We used only data from 2010 to 2014 because catch by mesh was not recorded prior to 2010. We calculated 80% confidence bounds around estimates of average daily catch rate and used those bounds to infer differences in catch rate between years. As in previous years absolute abundance of Lake Trout in Upper Priest Lake prior to netting removal was estimated using a Leslie Depletion Model incorporating catch rate as a function of cumulative Lake Trout catch (Ricker 1975). Cumulative Lake Trout catch was tallied by day for all mesh sizes fished. We used our depletion model to predict abundance when catch rate equaled zero.

All lake trout caught during netting efforts were measured to total length (mm) and examined for marks. Lake trout greater than 400 mm were primarily cleaned, packed on ice, and distributed to local food banks. Remaining lake trout were dispatched and returned to the lake. We evaluated the significance of net mesh size on the length of collected Lake Trout by comparing variation in total length within mesh sizes using a Kruskal-Wallis non-parametric analysis of variance procedure ($\alpha = 0.05$).

Bycatch associated with the removal effort was generally noted and released, though not all species were recorded. However, total length, condition, and genetic samples were collected from all Bull Trout. We reported Bull Trout catch rate as total catch divided by total effort among all mesh sizes and compare catch rate between 2007 and 2014.

We used recapture rates of previously tagged fish in Upper Priest Lake to estimate our exploitation of Upper Priest Lake Lake Trout during removal efforts. In April 2013, 87 Upper Priest Lake Lake Trout were collected and marked with T-bar style tags in Upper Priest Lake (Personal Communication, Elizabeth Ng, University of Idaho). All Lake Trout captured during the 2014 removal effort were examined for tags. We calculated exploitation as the percent of tags at large caught during removal efforts. We accounted for tags removed from the population by 2013 Lake Trout removal efforts and subsequent angler harvest by reducing the total tags at large accordingly. Six fish were removed from Upper Priest Lake by netting in 2013. One fish was caught and tag reported by an angler. Although this fish was released it was reportedly caught and released in Priest Lake and therefore was removed from the vulnerable population. Adjusted exploitation rate (μ') incorporated estimates of tag loss using the following formula as described by Meyer et al. (2012):

$$\mu' = \frac{\mu}{\lambda(1 - Tag_l)(1 - Tag_m)}$$

Defined terms included: μ the unadjusted exploitation rate (the number of non-reward tags recovered from fish that were harvested divided by the number of fish released with non-reward tags), λ the angler tag reporting rate, Tag_l tag loss, and Tag_m the tagging release mortality rate. Our tag reporting rate was 100%. We utilized a tag loss rate of 12.7% estimated for wild trout in Idaho (Meyer et al. 2012) and a release mortality rate of 20% estimated for Lake Trout caught and tagged in Priest Lake in 2013 (personal communication, Elizabeth Ng, University of Idaho). We calculated a secondary estimate of adjusted exploitation that applied an addition 30% mortality associated with natural mortality and emigration from Upper Priest Lake to Priest Lake. We assigned this value somewhat arbitrarily having limited information to assess natural mortality or emigration rates. As such we used this secondary value to qualitatively assess a potential range of exploitation based on our removal efforts.

In a companion effort, we also sampled Westslope Cutthroat Trout in an effort to establish a monitoring tool to evaluate changes in abundance associated with Upper Priest Lake management activities. We collected Westslope Cutthroat Trout using 45 x 1.8 m monofilament experimental floating gill nets. Gill nets were constructed with six panels and included mesh sizes of 1.9, 2.5, 3.2, 3.8, 5.1, and 6.4 cm bar mesh. Nets were set perpendicular to the shoreline in near shore areas at randomly chosen locations. All nets were fished overnight with set times of approximately 10 to 12 h. All fish collected were measured (TL, mm). Relative abundance of Westslope Cutthroat Trout was described as catch per net.

RESULTS

We collected 2,494 Lake Trout during the seven-day effort. Average daily catch rate from standard mesh sizes was 21.5 fish/box (± 6.9, 80% C.I.), an increase from 2013 (Figure 28). However, overlapping confidence intervals around average catch rates suggested differences were not significant among any year since 2010.

Catch rate generally declined as cumulative Lake Trout catch increased, suggesting we depleted the initial population over the seven day effort (Figure 29). We estimated abundance prior to our removal effort at 3,025 fish suggesting we exploited approximately 82% of the population during our removal effort.

We recaptured twelve Lake Trout tagged in Upper Priest Lake in 2013. We estimated 56 to 39 tagged fish were at large based on applied corrections. Adjusted exploitation from Upper Priest Lake Lake Trout removal efforts from tagged fish returns ranged between 21% and 31%. In addition, six Lake Trout previously tagged in Priest Lake in 2013 were also recaptured during removal efforts. We were unable to determine what contribution Priest Lake tagged fish captures represented in Upper Priest Lake. However, based on proportions of tagged fish in the catch we speculated a significant number of Priest Lake fish were recent (post spring 2013) immigrants from Priest Lake.

Total lengths of gill net caught Lake Trout varied by mesh size (Figure 30). Lake Trout length ranged from 191 to 877 mm (Figure 31). In general, fish length increased with increased gill net mesh size. Differences in total length of Lake Trout collected in small mesh sizes (45, 51, 64, and 76 mm) were significant (Kruskal Wallis ANOVA, $P \leq 0.05$). Lake Trout captured in larger net mesh sizes (76–127 mm) did not represent significant differences in length. Small mesh sizes (45, 51, and 64 mm) represented the highest catch rates and accounted for 87% of the total catch.

Incidentally caught species included Bull Trout, Kokanee *Oncorhynchus nerka*, Longnose Sucker *Catostomus catostomus*, Largescale Sucker *C. macrocheilus*, Mountain Whitefish *Prosopium williamsoni*, Northern Pikeminnow *Ptychocheilus oregonensis*, Peamouth *Mylocheilus caurinus*, Westslope Cutthroat Trout, and Yellow Perch *Perca flavescens*. Bull Trout catch rate (0.26/box) was close to the average catch rate for previous eight-year period (0.21 Bull Trout per box). However, we caught 46 Bull Trout in 2014 representing a greater catch than any previous year since 2007. A week, but positive trend in Bull Trout abundance was observed since 2007 (Figure 32).

In gill nets set for Westslope Cutthroat Trout, we observed an average catch rate of 3 (± 2, 80 C.I.) Westslope Cutthroat Trout per net. Total length of capture Westslope Cutthroat Trout ranged from 176 to 421 mm (Figure 33). We collected seven additional species including Bull Trout (1.2/net), Kokanee (0.2/net), Lake Trout (0.3/net), Mountain Whitefish (0.5/net), Northern Pikeminnow (21.8/net), Peamouth (1.0/net), and Yellow Perch (0.2/net).

DISCUSSION

Evaluation of exploitation rates and depletion trends suggested estimates reported in past years may have overestimated the percentage of the population removed each year. A linear modeling approach based on fishing success (Leslie method, Ricker 1975) has been used to predict abundance prior to annual removal and a subsequent exploited proportion of the population since 2007 (Dupont et al. 2011, Fredericks et al. 2009, Hardy et al. 2010, Maiolie et al. 2011, Fredericks et al. 2013, Maiolie et al. 2013, and Ryan et al. 2014). Estimates of exploitation from those analyses, including 2014, typically suggested removal efforts accounted for 80% or more of the existing population. Our analysis of tagged fish recaptures in 2014 suggested estimates of exploitation were at least 63% lower than those based on depletion. Dupont et al. (2011) and Fredericks et al. (2009), found similar discrepancies with exploitation estimates from tagged fish recaptures at 36% to 53% lower than rates estimates from fishing success methods. Although we were not able to clearly define the cause of these discrepancies, we speculated inconsistent catchability may be a factor. Ricker (1975) indicated fishing based methods for estimating abundance are sensitive to inconsistent catchability. Some evidence exists that lake trout catchability may not remain constant through time when heavy fishing effort is applied. As an example, catch rates for Lake Pend Oreille Lake Trout have been observed to decline when heavy fishing pressure was applied to targeted areas of the lake (personal communication, Nick Wahl, IDFG). Resting heavily-fished areas for days or weeks then resulted in increased catch rates when fishing pressure was subsequently re-applied. If variation in catchability occurs during Upper Priest Lake efforts, exploitation rates based on tagged fish recovery may be more accurate representations of the impact from annual Lake Trout removal efforts. However, tagging sample fish pre-removal is likely not feasible on an annual basis. We recommend alternative methods of monitoring population impacts resulting from removal efforts be considered. A likely alternative would be the use of catch rates from standardized gear.

Although maximizing the number of Lake Trout removed from Upper Priest Lake remains a priority for meeting objectives of population reduction in Upper Priest Lake, maintenance of a monitoring tool within removal efforts is critical for gauging the success of this long-term population manipulation. Gill net mesh sizes and quantities fished during Upper Priest Lake removal efforts have varied considerably between years, confounding inferences regarding annual change in catch and abundance. Standardizing a range of gill net mesh sizes and quantities between 38 mm and 127 mm is recommended for future efforts to maximize the portion of the population represented by the catch. Although catch within the recommended mesh size range in 2014 was not truly independent within all meshes, it provided some evidence a suite of mesh sizes provided greater opportunity for collection of a representative range fish of varying length. We also recommend gear be standardized within units or time frames (i.e. gill nets size and quantity fished during one day) to maximize the ability to track relative changes in abundance from year to year represented by the catch.

Catch rates in standard gill nets since 2010 suggested abundance of Lake Trout recruited to the gear has not significantly changed despite continued annual removal efforts. Estimates of exploitation suggested we removed a substantial proportion of the Upper Priest Lake Lake Trout population within years, however recruitment from within Upper Priest Lake and or by immigration from Priest Lake may have compensated for removals between years. We were not able to estimate recruitment within Upper Priest Lake in our analyses. However, we did observe substantial immigration rates from Priest Lake as tagged fish recaptured in Upper Priest Lake. In Priest Lake, annual mortality rates upwards of 25% or greater have been estimated as necessary to achieve negative population growth (personal communication, Elizabeth Ng, University of Idaho). Although we likely achieved mortality rates of this level or greater through gill netting in recent years, Priest Lake immigration may have compensated for our removal.

Bull Trout catch rates suggested their abundance in Upper Priest Lake has increased since 2007 in concert with continued Lake Trout removal efforts. Upper Priest River Bull Trout redd counts also demonstrated a similar trend (see Panhandle Bull Trout Redd Count Summary in this report). Though speculative, it seems plausible that removing Lake Trout from Upper Priest Lake has played some role in Bull Trout abundance.

Our floating gill net survey provided a basis to evaluate changes in Westslope Cutthroat Trout abundance associated with Upper Priest Lake Lake Trout removal efforts. We recommend periodic sampling of Westslope Cutthroat Trout using standardized floating gill nets as a continuation of this monitoring tool.

MANAGEMENT RECOMMENDATIONS

1. Continue annual gillnetting on Upper Priest Lake in support of native fish.

2. Continue application of consistent gear types and effort quantities during Upper Priest Lake netting to allow for inference relative to changes in the Lake Trout population and impacts of removal efforts.

3. Discontinue the use of the Leslie Depletion method for estimation of Lake Trout abundance in Upper Priest Lake.

4. Maintain periodic monitoring of Westslope Cutthroat Trout using standardized floating gill nets to evaluate trends relative abundance.

Table 9. Upper Priest Lake 2014 gill net effort and Lake Trout (LKT) catch by gill net mesh size. Total length (mm, TL) ranges of Lake Trout caught were reported by associated gill net mesh sizes.

Mesh	Effort (m)	% of Total effort	LKT caught	LKT/box	Min TL	Max TL
45 mm	9876	20%	488	14	191	877
51 mm	9876	20%	793	22	234	727
64 mm	9876	20%	894	25	236	871
76 mm	3292	7%	147	12	284	852
89 mm	3292	7%	62	5	355	778
102 mm	6584	13%	63	3	266	829
114 mm	3292	7%	23	2	371	816
127 mm	3292	7%	24	2	231	834

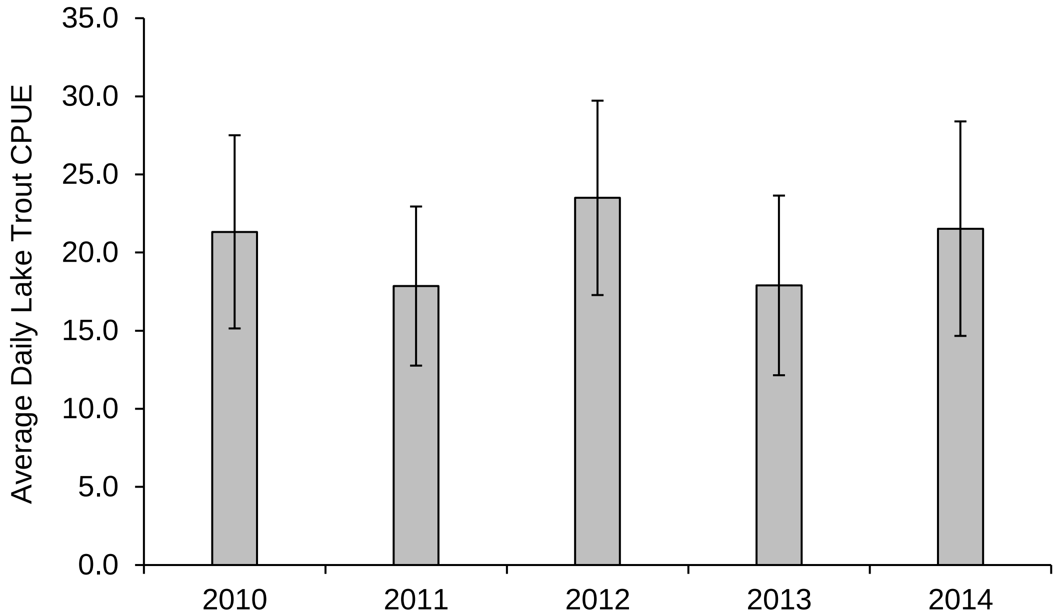

Figure 28. Average daily Lake Trout catch rates and 80% confidence intervals from standard gill net mesh sizes (51 mm, 64 mm, and 76 mm) fished between 2010 and 2014.

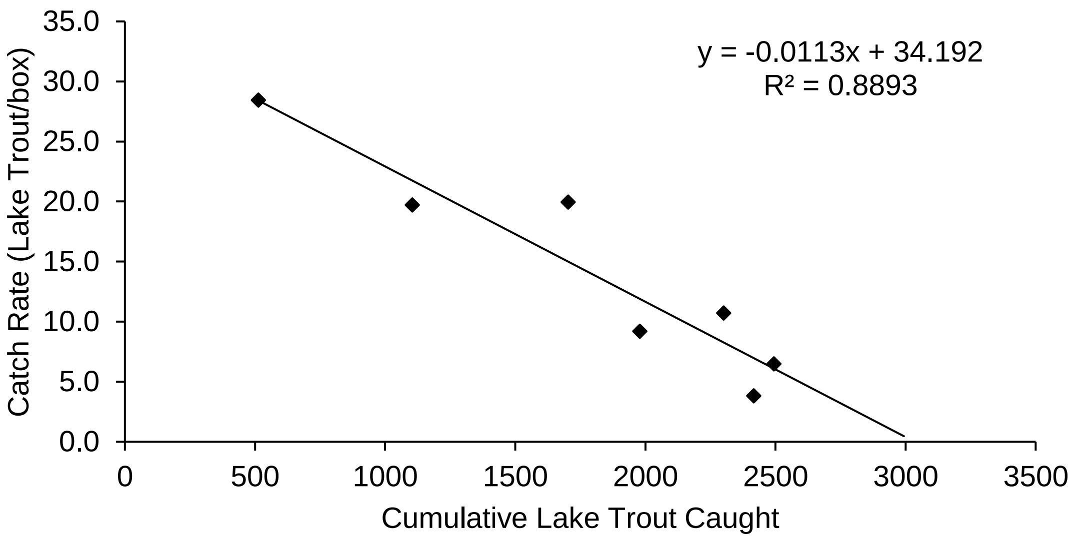

Figure 29. Cumulative Lake Trout catch plotted against catch rate (Lake Trout per box of net fish, CPUE) from Upper Priest Lake Lake Trout removal efforts in 2014. Lake Trout abundance in Upper Priest Lake was estimated by predicting the cumulative catch equal to a catch rate of zero.

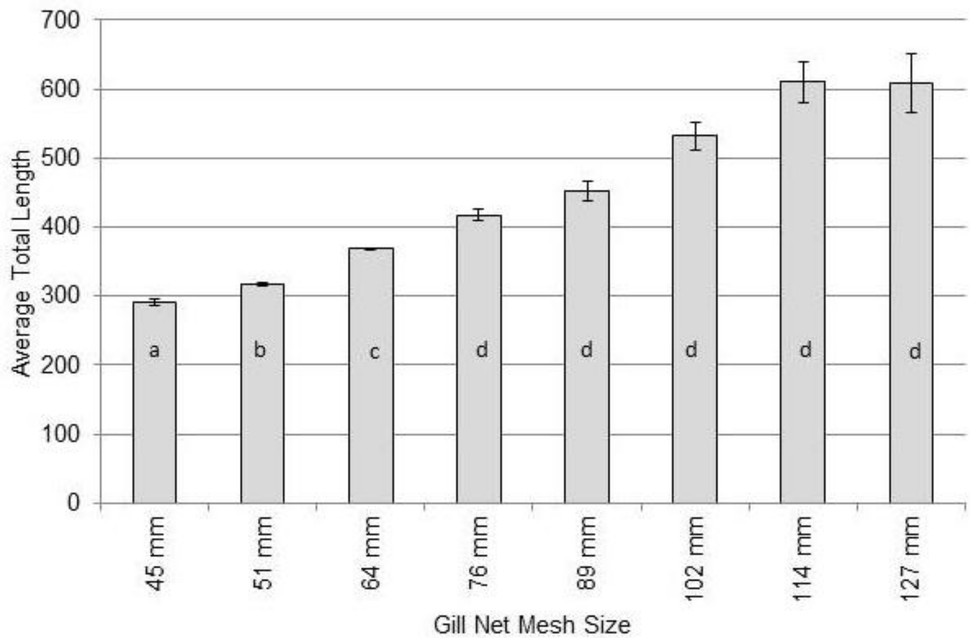

Figure 30. Average total length of Lake Trout caught within gill net mesh sizes fished. Mesh sizes with differing subscripts represented significantly different lengths in the catch.

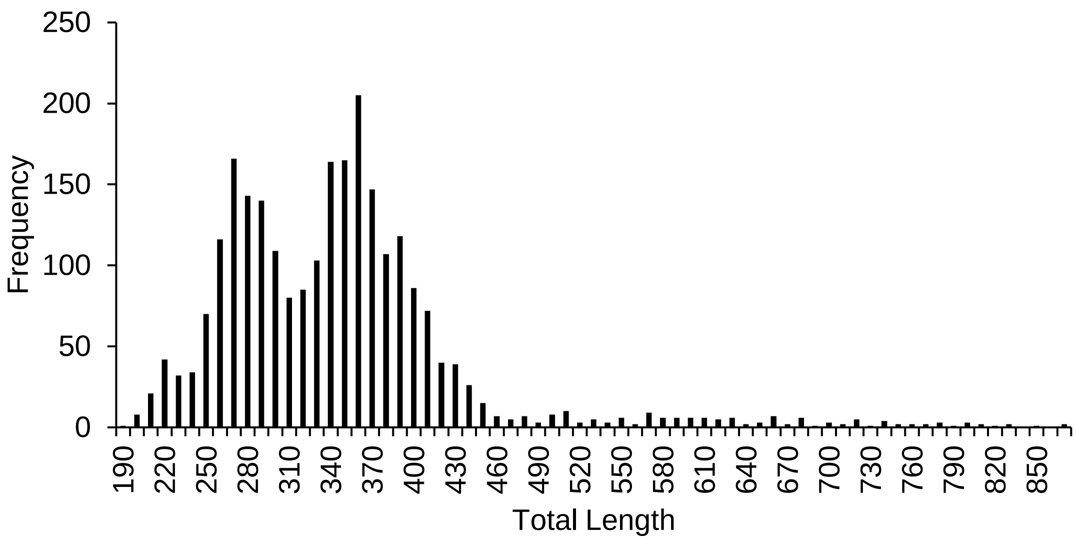

Figure 31. Frequency of total lengths from Lake Trout collected in Upper Priest Lake during 2014 gill net effort completed to reduce Lake Trout abundance.

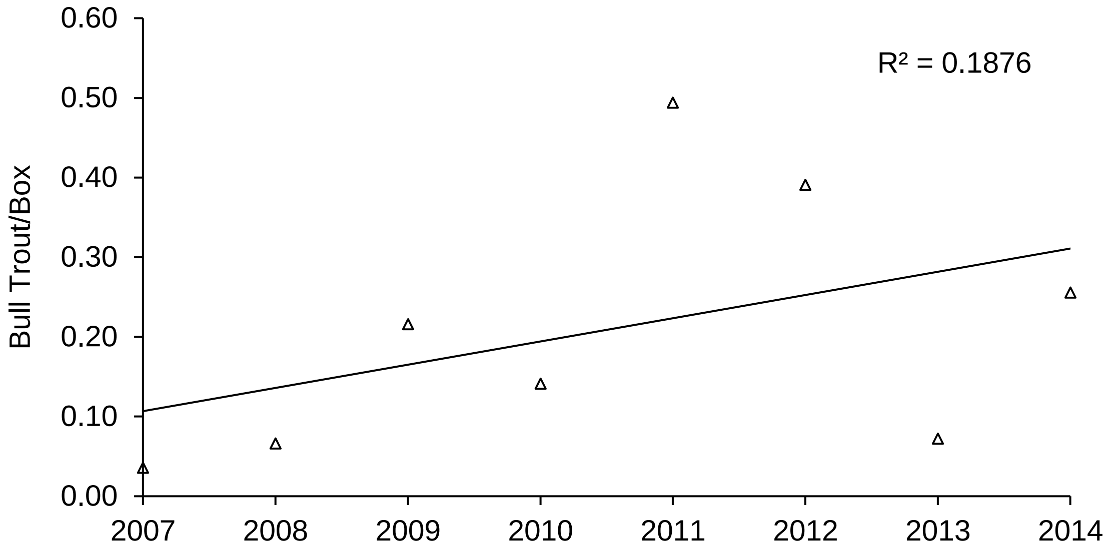

Figure 32. Bull Trout catch rate (fish/box, calculated as total catch divided by total effort) from Upper Priest Lake gill netting efforts between 2007 and 2014.

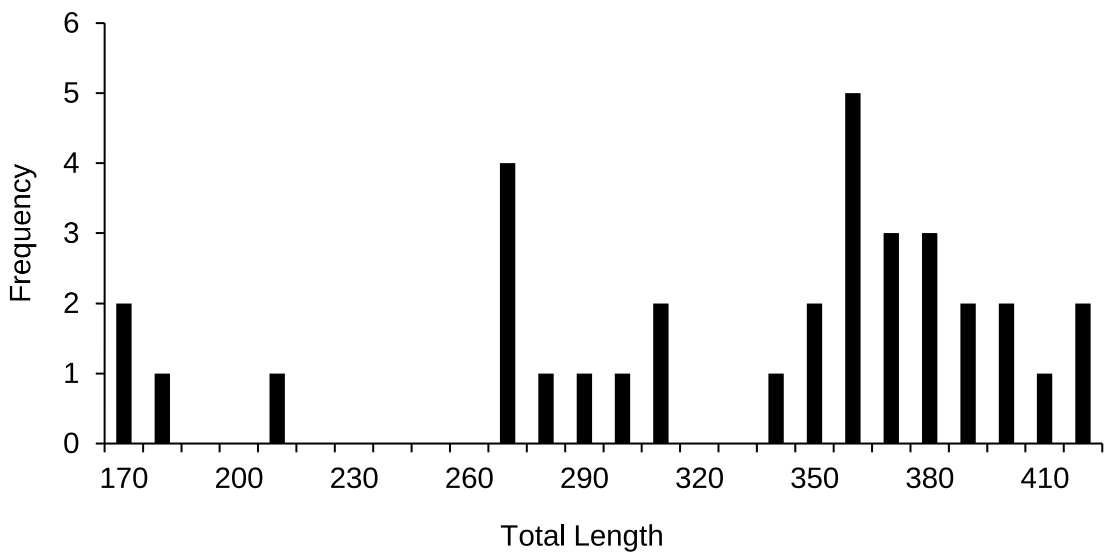

Figure 33. Length-frequency histogram for Westslope Cutthroat Trout collected in Upper Priest Lake in floating experimental gill nets in 2014.

NORTH IDAHO BLACK CRAPPIE INVESTIGATIONS

ABSTRACT

Black Crappie provide popular sport fisheries in several of Idaho's northern lakes. Although typically managed for high yield with unlimited harvest in Idaho, a minimum length restriction was placed on Hayden Lake and was thought to be influential in increasing the availability of fish 254 mm and larger. Other regional waters, such as Twin Lakes and Fernan Lake, provide popular Black Crappie fisheries with no harvest restrictions. Anecdotal information from anglers suggested average Black Crappie size in the catch at these waters is smaller than that observed in Hayden Lake. Beyond anecdotal evidence, no formal evaluation of regional Black Crappie populations has been completed to determine if minimum length limits truly improved the Hayden Lake fishery and if harvest restrictions might benefit other northern Idaho populations. Our objectives were to describe the general dynamics of Black Crappie populations in three northern Idaho lakes and to evaluate the utility of harvest restrictions for increasing abundance of Black Crappie equal or greater than 254 mm while maintaining harvest opportunities. We sampled Black Crappie between April 18 and May 13, 2014 on three regional lakes using multiple gear types to describe relative abundance, growth, and mortality. We also applied Beverton-Holt yield per recruit models in FAST to predict the impact of a 254-mm minimum length limit on abundance and yield in the targeted lakes. Relative abundance was highly variable between lakes and ranged from 1 to 18 fish per unit effort. Growth varied among lakes, with six to nine years required for Black Crappie to reach 254 mm. Annual mortality ranged from 41% to 61%. Abundance of Black Crappie greater than 254 mm increased as did fishery yield when growth was sufficiently fast and natural mortality was low to moderate. When growth was slow, little to no benefit was predicted by applying a minimum length limit. Our work indicated minimum length restrictions are likely suitable for Hayden Lake, but would not benefit the fishery in Twin Lakes.

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INTRODUCTION

Black Crappie *Pomoxis nigromaculatus* were introduced to many of Idaho's northern lakes during the early 1900s (IDFG, unpublished data). Where abundant, Black Crappies provide popular sport fisheries. Targeted angler effort and associated catch of Black Crappies is significant in some of the region's lakes (Maiolie et al. 2011, Fredericks et al. 2013).

Although typically managed for high yield with no harvest restrictions in Idaho, Black Crappie harvest was restricted in Hayden Lake beginning in 1990 due to concerns of overexploitation on large crappie (Maiolie et al. 1991). Current regulations include a minimum length limit of 254 mm and a harvest limit of six per angler day. Although atypical of crappie management in Idaho, the rule has been considered effective and Black Crappie in Hayden Lake are thought to be larger than in other regional waters, providing a quality fishing experience. Other regional waters, such as Twin Lakes and Fernan Lake, provide popular Black Crappie fisheries with no harvest restrictions. Anecdotal information from anglers suggests average Black Crappie size in the catch at these waters is smaller than that observed in Hayden Lake. Angler exploitation of Black Crappie in Hayden Lake has been estimated at over 30% with harvest restrictions in place. Angler exploitation of Black Crappie in other waters of the region has not been estimated in recent years.

Understanding fish growth is important in predicting the influence of minimum length limits on fish populations. Growth rates of Black Crappie in northern Idaho lakes are not clearly understood. Where investigated, information on growth rates are conflicting and suggest crappie growth varies within waters and between waters in the Panhandle Region (Davis and Horner 1995, Nelson et al. 1996). However, sample sizes used in these evaluations have been limited, and as such may have prohibited accurate portrayal of Black Crappie growth in regional lakes. Statewide evaluations of Black Crappie growth suggested Hayden Lake fish grow at rates comparable or higher than other selected waters around the state (Lamansky 2011).

Understanding the influence of Black Crappie harvest restrictions on size structure is important not only to insure harvest restrictions are effective where currently applied on Hayden Lake, but also to evaluate their application on other northern Idaho waters. Restrictions such as minimum length limits are likely only effective when crappie populations experience rapid growth and low natural mortality (Allen and Miranda 1995). Available knowledge does not provide adequate information for judging whether northern Idaho Black Crappie population dynamics exhibit conditions suitable for effective use of such harvest restrictions.

Our objectives were to describe the general dynamics of Black Crappie populations in northern Idaho lakes and to evaluate the utility of harvest restrictions for increasing abundance of Black Crappie equal or greater than 254 mm while maintaining harvest opportunities.

STUDY SITE

Black Crappie were sampled from three waters in the Panhandle Region. We selected Twin Lakes, Hayden Lake, and Fernan Lake as our study waters for this investigation. These waters were selected because they support abundant Black Crappie populations and popular targeted crappie fisheries (Liter et al. 2007, Maiolie et al. 2011, and Fredericks et al. 2013).

All three sampled waters were located in the vicinity of Coeur d'Alene, Idaho. Twin Lakes are two connected natural water bodies located northwest of Rathdrum, Idaho. Upper Twin Lake (202 ha) and Lower Twin (142 ha) are connected by a short shallow thoroughfare. For the purpose of this investigation we considered these two water bodies as one study area. Twin Lakes has one primary inflow, Fish Creek, and one outflow, Rathdrum Creek. Hayden Lake is a 1,538 ha natural lake is located east of Hayden, Idaho. There are several small tributaries enter Hayden Lake including Hayden Creek, Yellowbanks Creek, and Mokins Creek. Hayden Lake outflows only during high water periods. Fernan Lake is a 182 ha natural lake located immediately north of Coeur d'Alene Lake, Idaho. The primary inflow to Fernan Lake is Fernan Creek. Outflow from Fernan Lake is via a short connecting stream to Coeur d'Alene Lake.

Fish communities in all three study waters are similar. Populations of warmwater fish including Black Crappie, Largemouth Bass *Micropterus salmoides*, Pumpkinseed *Lepomis gibbosus*, Yellow Perch *Perca flavescens*, black bullhead *Ameiurus melas* and northern Pike *Esox lucius* are found in all three waters. Rainbow Trout *Oncorhynchus mykiss* are stocked regularly in all three lakes. Kokanee *Oncorhynchus nerka* are also stocked regularly in Lower Twin Lake and Hayden Lake. Bluegill *Lepomis macrochirus* occur in Hayden and Fernan Lakes. Smallmouth Bass *Micropterus dolomieu* and Green sunfish *Lepomis cyanellus* occur only in Hayden Lake and Twin Lakes, respectively. Fernan Lake is also stocked with channel catfish *Ictalurus punctatus.*

Sampled waters represented both restricted harvest (Hayden Lake) and unrestricted harvest (Twin Lakes and Fernan Lake) regulations. In Idaho, unrestricted harvest (no size or bag limits) of Black Crappie is the general rule applied to most crappie fisheries. Hayden Lake represents the only restricted harvest regulation on Black Crappie in the state.

METHODS

We sampled black crappie between April 18 and May 13, 2014 to describe the general dynamics of Black Crappie populations in northern Idaho lakes and to evaluate the utility of harvest restrictions for improving average size in regional crappie fisheries. We used a simple random sampling design to designate sample locations. Each water body was broken into sample units by overlaying a numbered UTM grid. Sample sites were chosen randomly by first selecting a number grid followed by selection of one quarter within the numbered grid. Only shoreline oriented grids were selected because effective use of the selected sampling gears limited sampling effort to shallower near shore waters. We also used non-random site selection to test trap net effectiveness on Hayden Lake and to collect desired otolith samples for age estimation on Hayden and Twin lakes.

We sampled Black Crappie using a boat-mounted electrofisher. We also attempted to collect fish using Idaho Department of Fish and Game (IDFG) standard trap nets and floating gill nets. Trap nets were fished on Hayden Lake and Fernan Lake. Black Crappie were collected with gill nets only on Hayden Lake. We applied standard 600 second electrofishing effort units along shoreline habitats on all three lakes. We completed 10 units of electrofishing effort on Twin Lakes, eight units on Hayden Lake, and nine units on Fernan Lake. Trap nets were set perpendicular to the shoreline and fished for one overnight period per location. Six sample sites, three random and three non-random were fished with trap nets on Hayden Lake. Non-random sites were selected based on locations where Black Crappie were previously collected with other gears and used to test the effectiveness of trap nets for capturing Black Crappie. Six random sample sites were fished with trap nets on Fernan Lake. Gill net catches were made in random net sets incidental to other sampling efforts. We described relative abundance of Black Crappie as catch per unit effort (CPUE) from electrofishing captures only. Gill net caught fish were included in age estimation only.

Only Black Crappie were netted during electrofishing efforts. We noted other trap net species caught, but did not record information on individual bycatch. All Black Crappie collected were measured (mm) and weighed (g).

Black Crappie ages were estimated with otoliths collected from a representative portion of the fish sampled in each water body. We examined otoliths under a dissecting microscope in whole view or by breaking centrally, browning, sanding, and viewing the cross section. Three readers viewed each otolith and discrepancies between readers were solved by committee. If a consensus could not be reached the sample was excluded in analysis. We applied ages to non-aged fish by proportion in the subsample using an age length key (Isely and Grabowski 2007). Growth patterns were evaluated using estimated fish ages to determine mean length at age at time of capture. We also used catch at age as a measure of year class strength in evaluation of recruitment and mortality. Catch curves were used to estimate lake specific instantaneous mortality rates. We estimated mortality using fish between the ages of four and ten. Age classes one to three appeared to be underrepresented in the sample and were either not fully recruited to our gear or represented less robust cohorts. Maximum age observed in Hayden Lake was ten. Although maximum age in Twin Lakes was greater than ten, we did not incorporate these age classes because they were sporadically represented and represented by only single individual when present. No estimate of mortality was completed for Fernan Lake due to limited samples.

Regulation Modeling

We applied a Beverton-Holt yield per recruit model to evaluate the impact of harvest restrictions on abundance of Black Crappie equal or greater than 254 mm and fishery yield. Fisheries Analyses and Simulation Tools (FAST; Slipke and Maceina 2000) software was used to develop and run models. Primary model inputs included growth and mortality indices (Table 10). Fish growth was incorporated into our model in the form of linear coefficients for length-weight relationships and von Bertalanffy growth coefficients. Growth inputs were generated in FAST and were lake specific. Our model incorporated both conditional fishing (cf) and conditional natural (cm) mortality rates. We used a range of mortality rates rather than lake specific values. Conditional fishing mortalities ranged between 10% and 60% corresponding to approximate exploitation levels of 10% to 50%. Conditional natural mortalities ranged between 20% and 50%.

We confirmed mortality rates used in the model were reasonable using two approaches. First, we estimated cf and cm over a range of exploitation rates (20% to 50%) using our lake specific estimates of instantaneous mortality (Z). Mortality rates (cf and cm) were calculated as described in Miranda and Bettoli (2007) and Slipke and Maceina (2000). Second, we estimated instantaneous natural mortality and cm using five different computational mortality estimators available in FAST (Hoenig 1983, Jensen 1996, Peterson and Wroblewski 1984, Pauly 1980, and Chen and Watanabe 1989). These estimators relied on population characteristics such as maximum age and growth to predict natural mortality. We used these estimators only to provide a general reference of the range of mortality rates possible.

Exploitation of Black Crappie on Hayden Lake was previously estimated between 32% and 41% (Dupont et al. 2004, Liter et al. 2007, and Liter et al. 2009). We based our computations of cf and cm on a range of exploitation incorporating these values. Because no exploitation estimate was available for Twin Lakes, we applied the same range of exploitation values on that population. Our range of exploitation values and resulting cf values was large to accommodate for uncertainty in the true values.

We applied length-specific fishing mortality within the model to simulate two harvest restrictions including a no length restriction and a 254 mm (preferred length; Gabelhouse 1984) minimum length harvest restriction. We simulated the no length restriction by applying conditional fishing mortality rates to fish 150 mm and greater. We assumed, under no length restriction, anglers would not be willing to harvest Black Crappie less than 150 mm in length. This length represented a stock size fish (Gabelhouse 1984). Conditional fishing mortality was applied to fish 254 mm and greater to simulate a 254 mm length restriction. Current angling restrictions on Hayden Lake limit harvest to fish equal or greater than 254 mm. We applied fishing mortalities uniformly across designated size ranges. True fishing mortality may not be uniform across length, but no size specific harvest information was available for the selected waters.

Our model was used to describe the impact of a 254 mm length limit relative to no length limit. Model outputs included the proportion of a cohort reaching 254 mm, the proportion of a cohort removed by natural mortality, and yield over the life span of a cohort. Model outputs were described as a percent change between the two modeled regulations.

RESULTS

Twin Lakes

We collected a total of 32 Black Crappie from Twin Lakes from random electrofishing sites (Table 11). Average CPUE was 4 (± 2, 80% CI). An additional 61 fish were collected in association with non-random effort and used to estimate fish growth.

Thirteen age-classes were present within our electrofishing sample (Figure 34). The age distribution was dominated by age-4 and age-5 individuals (78%). The maximum age observed was fifteen years of age. We estimated annual mortality between age classes four and ten at 41% (Figure 35).

Total length of Black Crappie ranged from 116 to 307 mm (Figure 36). Based on our sample it took over nine years for an individual Black Crappie to reach 254 mm (Figure 37). Proportional stock density (PSD) of collected fish was 94.3 (89.5–99.2, 95% CI). Black Crappie weights ranged from 21 to 487 g.

Hayden Lake

We collected a total of 140 Black Crappie from Hayden Lake among all electrofishing sites (Table 11). Average CPUE was 18 (±4, 80% CI). No Black Crappie were collected in trap nets. We collected 42 Black Crappie in one gill net set. Gill net caught fish were not included in any measure of relative abundance, but were utilized in estimation of length at age.

Seven year-classes were present within our electrofishing sample (Figure 34). Age structure was dominated with age-4 and age-5 individuals, with a maximum age of ten years. Maximum age observed was ten years of age. We estimated annual mortality between age classes four and ten at 61% (Figure 35).

Total length of collected crappie ranged from 159 to 326 mm (Figure 36). Based on our sample, it took just over five years for an individual Black Crappie to reach 254 mm in Hayden Lake (Figure 37). Proportional stock density (PSD) of collected fish was 86.8 (81.4–92.2, 95% CI).

Fernan Lake

Few Black Crappie were caught during sampling efforts on Fernan Lake (Table 11). We captured 18 individuals among all electrofishing sites. Average CPUE was 1 (±1, 80% CI). No Black Crappie were caught in random trap net sets.

Three year-classes were present within our electrofishing samples of Fernan Lake (Figure 34). Collections were dominated by individuals representing age one fish. Maximum age observed was four years of age.

Total length of collected crappie ranged from 131 to 261 mm (Figure 36). Based on our sample it took approximately four years for an individual Black Crappie to reach 254 mm (Figure 37). Proportional stock density (PSD) of collected fish was 33.3 (11.6–55.1, 95% CI).

We did not complete a modeling effort for Fernan Lake. We deemed our collection of Black Crappie to be too small to provide confidence in the information gained. Inaccurate descriptions of growth were our primary concern.

Regulation Modeling

Our model predicted a large proportion of the Black Crappie populations in both Twin and Hayden Lakes were removed by natural mortality under both regulation scenarios. The proportion of the Twin Lakes population that was removed from natural mortality was variable and ranged from 44% to 96% with no length limit and increased 4% to 44% after applying a 254 mm length limit. Natural mortality in Hayden Lake was similar at 49% to 97% and increased 3% to 28% after applying a length limit. In general, natural mortality removed the largest proportion of the modeled population when cm was high.

Application of a 254-mm minimum length limit was not predicted to be effective at improving population structure or yield of Black Crappie in Twin Lakes. Fish growth was too slow to achieve a 254 mm length within the average life span of a cohort. As a result, a majority of the cohort was removed by natural mortality before fish could be legally harvested. Only a small proportion of Black Crappie in Twin Lakes achieved 254 mm within their life span. Up to 8% of the Twin Lakes population was predicted to achieve 254 mm before being removed either through fishing or natural mortality with no length limit applied. The proportion increased up to 16% after applying a 254-mm length limit when cm was low, but no more than 5% of the population reached 254 mm at cm of 30% or greater (Figure 38). The impact to harvest opportunity was apparent with predicted yield declining substantially under a 254-mm minimum length limit. We predicted yield was negatively impacted by the application of the length limit over the entire range of cm modeled in Twin Lakes (Figure 39). The impact of the length restriction generally diminished as exploitation increased.

Hayden Lake fish grew faster resulting in a greater proportion achieving 254 mm. Our model predicted up to 20% of the population achieved 254 mm with no length limit applied. The proportion increased after applying a 254-mm minimum length, with up to 29% of the population achieving 254 mm when cm was low (Figure 38). Intuitively, as cm increased the proportion of the population achieving 254 mm declined, but at a slower rate than observed in Twin Lakes. In the Hayden Lake model, we predicted that yield would increase more than 40% when cm was low and cf was high (Figure 39). Although, negative shifts in yield occurred across the range of cm, reductions were less severe than observed in the Twin Lakes model. At moderate cm and cf levels (cm = 30% and cf = 30% to 50%) reductions in yield ranged from -4% to -21%.

DISCUSSION

Substantial differences were observed in relative abundance, growth, and mortality between surveyed lakes that likely impact the dynamics and fishery performance of each population. Based on our model predictions, regulating harvest by limiting minimum length of harvested fish, would not be effective at substantially increasing the availability of preferred size Black Crappie or fishery yield in Twin Lakes. In contrast, modeled abundance and yield of Black Crappie were improved by application of a 254-mm minimum length limit in Hayden Lake. Although positive benefits to the Hayden Lake fishery were predicted by applying a minimum length limit, those benefits were reduced when natural mortality was high. We estimated natural mortality of Black Crappie in Hayden Lake was moderate and therefore would expect some benefit in both availability of large crappie and increase or maintenance of yield. Hayden Lake, currently under a 254 mm minimum length limit, has provided a unique opportunity in the Panhandle region to catch Black Crappie of preferred size and larger. The performance of this fishery under the existing regulation supports the utility of the model in predicting crappie population responses.

The benefits of a restrictive length limit on northern Idaho Black Crappie fisheries was heavily influenced by growth rate. This was not surprising as others have noted success of minimum length restrictions are reliant on a balance of sufficient growth and low natural mortality (Brousseau and Armstrong 1987; Allen and Miranda 1995). In our modeling approach, only growth variables were truly independent between populations. We described considerably faster growth for Hayden Lake fish. Consistent with the observations of others, minimum length limits provided little benefit when growth was slow as described in the Twin Lakes population.

Natural mortality, although applied as a consistent range of values in both of our modeled populations, also influenced the success of a minimum length limit. In our models, both abundance and yield were dramatically reduced as natural mortality rates increased. Impacts of a minimum length limit were generally unaffected by fishing mortality. Boxrucker (2002) also found exploitation on White Crappie had limited impact on fishery yield especially when natural mortality was high. We found little evidence, within the modeled range of fishing mortality, that exploitation negatively impacted either abundance or yield. Only slight reductions in abundance and yield occurred under no length limit when natural mortality was low and exploitation was high.

Variable recruitment is a common phenomenon observed in crappie populations (Hooe 1991; Allen and Miranda 2001) and was evident in all three of our surveyed lakes. Variable recruitment likely impacted our ability to accurately estimate mortality rates using catch at age from a single sample. Although moderate and random variation in recruitment may not impact estimates of mortality from catch curves (Ricker 1975; Miranda and Bettoli 2007), we observed dramatic variation in catch at age throughout the represented age classes in all three surveyed water bodies. We recommend consecutive sampling or pooled samples from multiple year sampling events be used to mediate the variability in year-class strength and provide more precise estimates of mortality.

We did not address the impact of highly variable recruitment in combination with minimum length limits on fishery performance in our investigation. Although not addressed, others have suggested length limits may act to minimize the impact of variable recruitment on crappie population structure by protecting smaller fish that might be targeted when larger fish are reduced by anglers or between years of good recruitment (Webb and Ott 1991; Boxrucker 2002). Our modeling suggested minimum length limits may increase predictability of fishery performance, but only when growth and mortality are reasonable.

MANAGEMENT RECOMMENDATIONS

1. Maintain existing management of crappie fisheries evaluated in this survey

2. Evaluate growth prior to considering new management regulations on other crappie fisheries

Table 10. Model parameters used in yield per recruit models for Twin and Hayden lakes

ModelParameter	Description	Twin Lakes	Hayden Lake
Min TL	minimum harvest length	150/254	150/254
N_0	initial population size	1000	1000
b	weight:length function slope	3.093	3.273
a	weight:length function intercept	-5.06	-5.472
W_{inf} (g)	max theoretical weight	303	893
Max Age	max age in the population	15	10
L_{inf} (mm)	max theoretical length	274	374
K	growth coefficient	0.269	0.176
t_0	theoretical time at TL = 0	-1.35	-0.911

Table 11. Total number of sampled fish (n), age at 254 mm, length range, catch per unit effort (CPUE), maximum age observed (Max Age), proportional stock density (PSD) and total annual mortality (AM) of Black Crappie collected from three northern Idaho Lakes in 2014.

Water	n	Age @ 254 mm	TL range (mm)	CPUE	Max age	PSD	AM
Twin Lakes	93	9.6	116-307	4	15	94	0.41
Hayden Lake	182	6.4	159-326	18	10	87	0.61
Fernan Lake	18	4.0	131-261	1	4	33	-

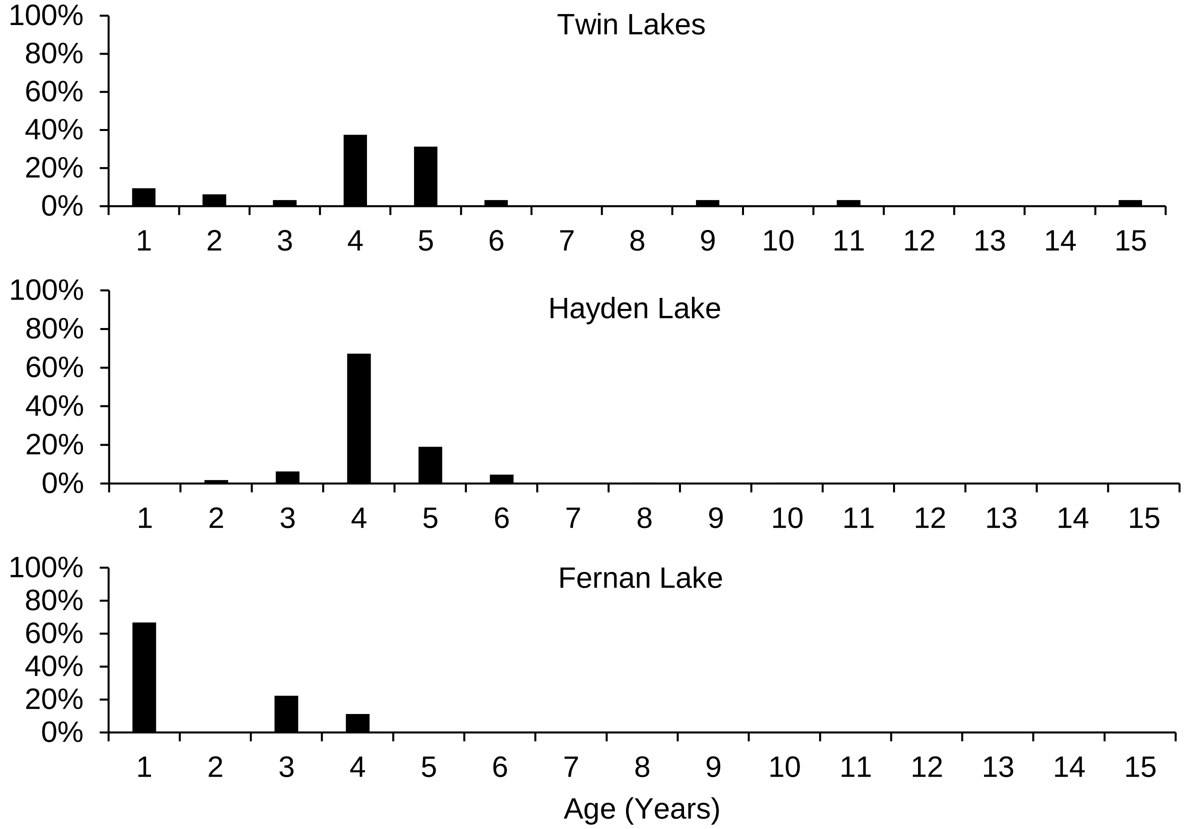

Figure 34. Proportions of Black Crappie by age collected from three northern Idaho Lakes in 2014.

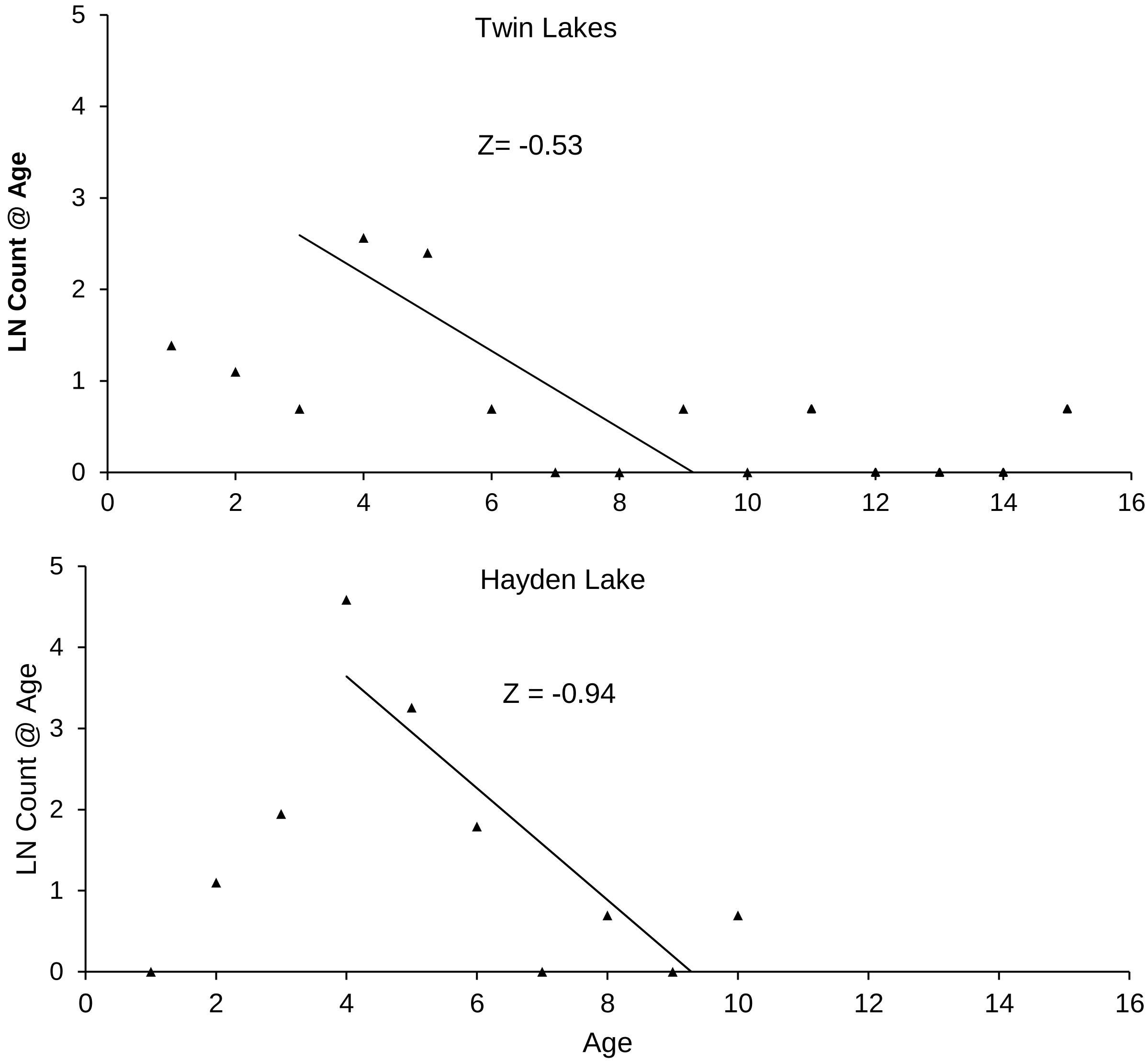

Figure 35. Catch curves used to estimate instantaneous mortality plotting the natural log (LN) of catch at age data for two north Idaho Black Crappie populations. Mortality was estimated between ages four and ten for both populations.

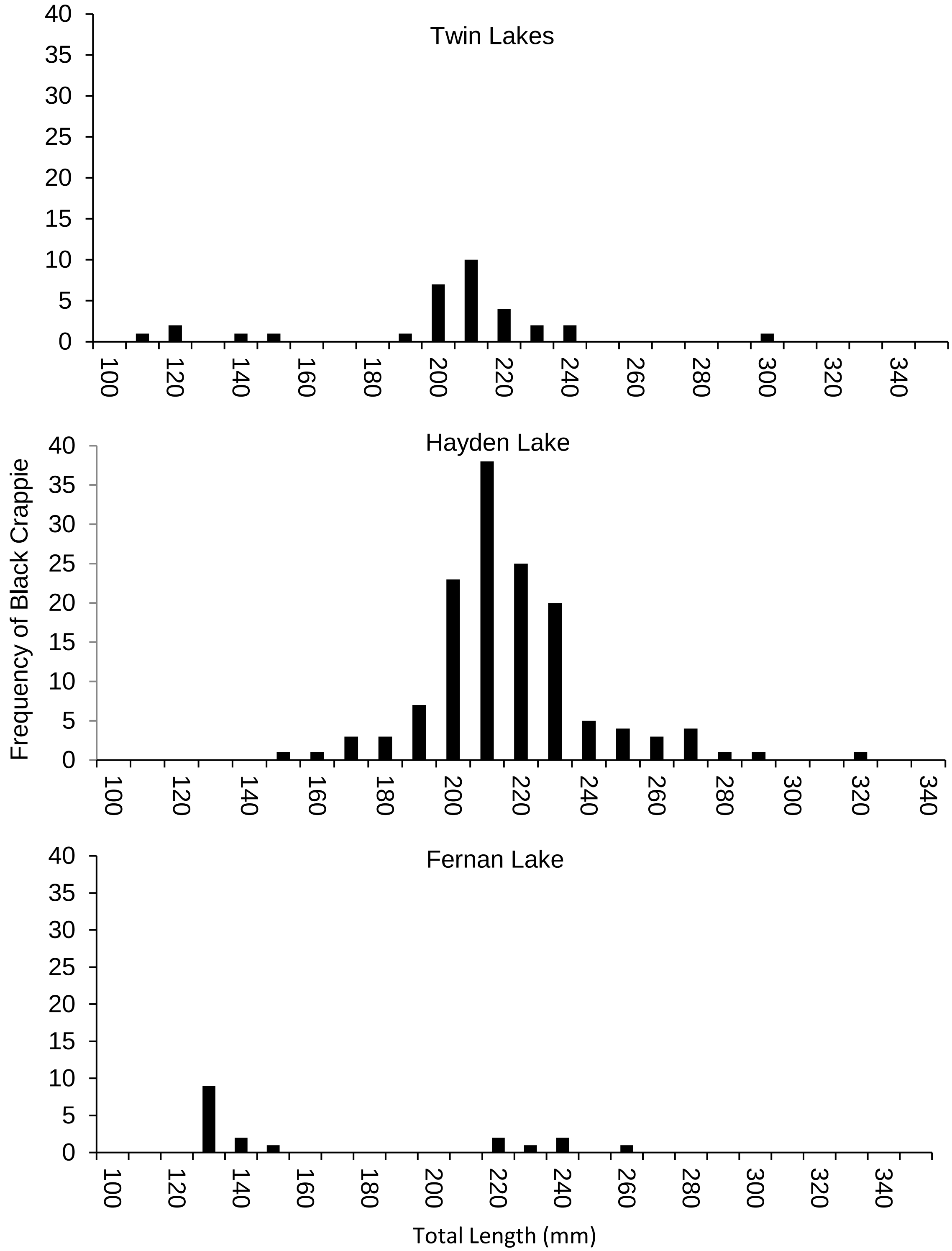

Figure 36. Frequencies of Black Crappie sampled by length in three northern Idaho lakes in 2014.

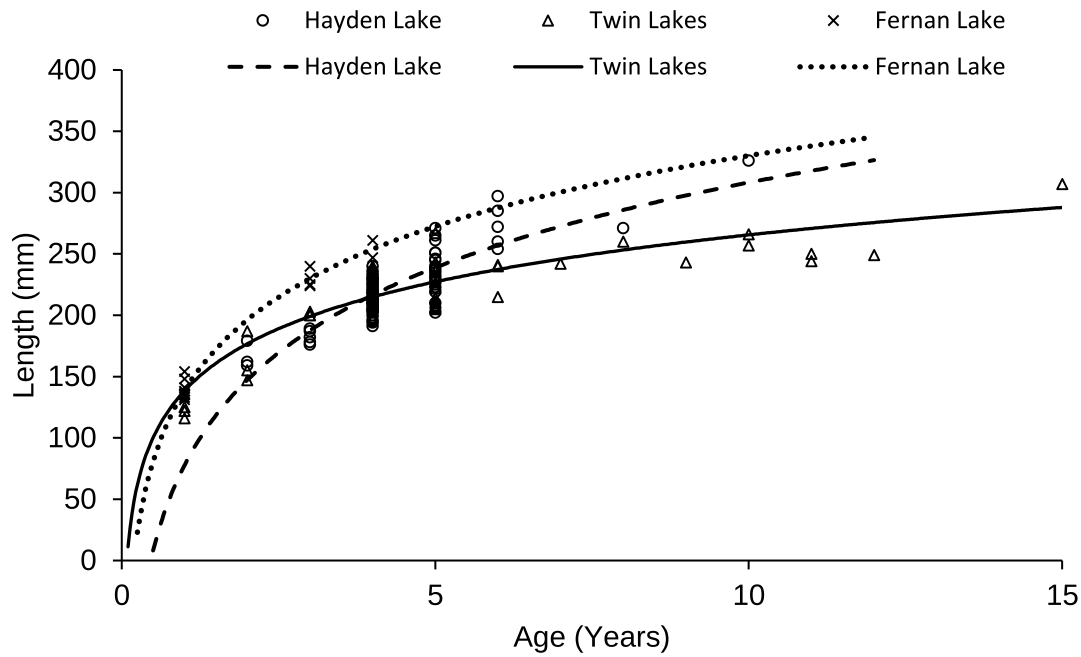

Figure 37. Total length at age at time of capture of Black Crappie collected from three northern Idaho lakes in 2014.

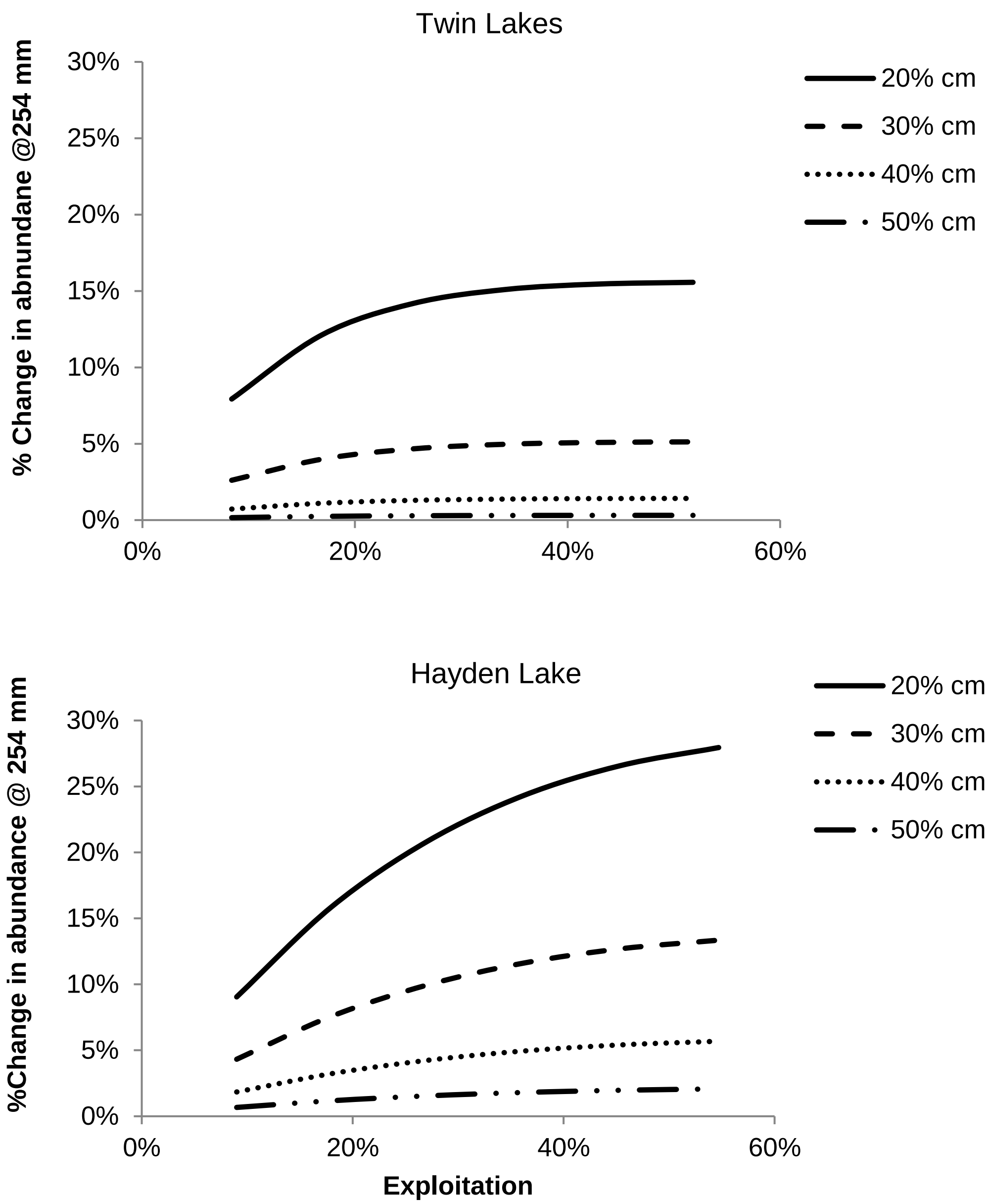

Figure 38. Predicted change in abundance of Black Crappie ≥ 250 mm in Twin and Hayden lakes after applying a 250 mm minimum length limit. Abundance was modeled over a range of exploitation and varied by levels of conditional natural mortality (cm) from 20% to 50%.

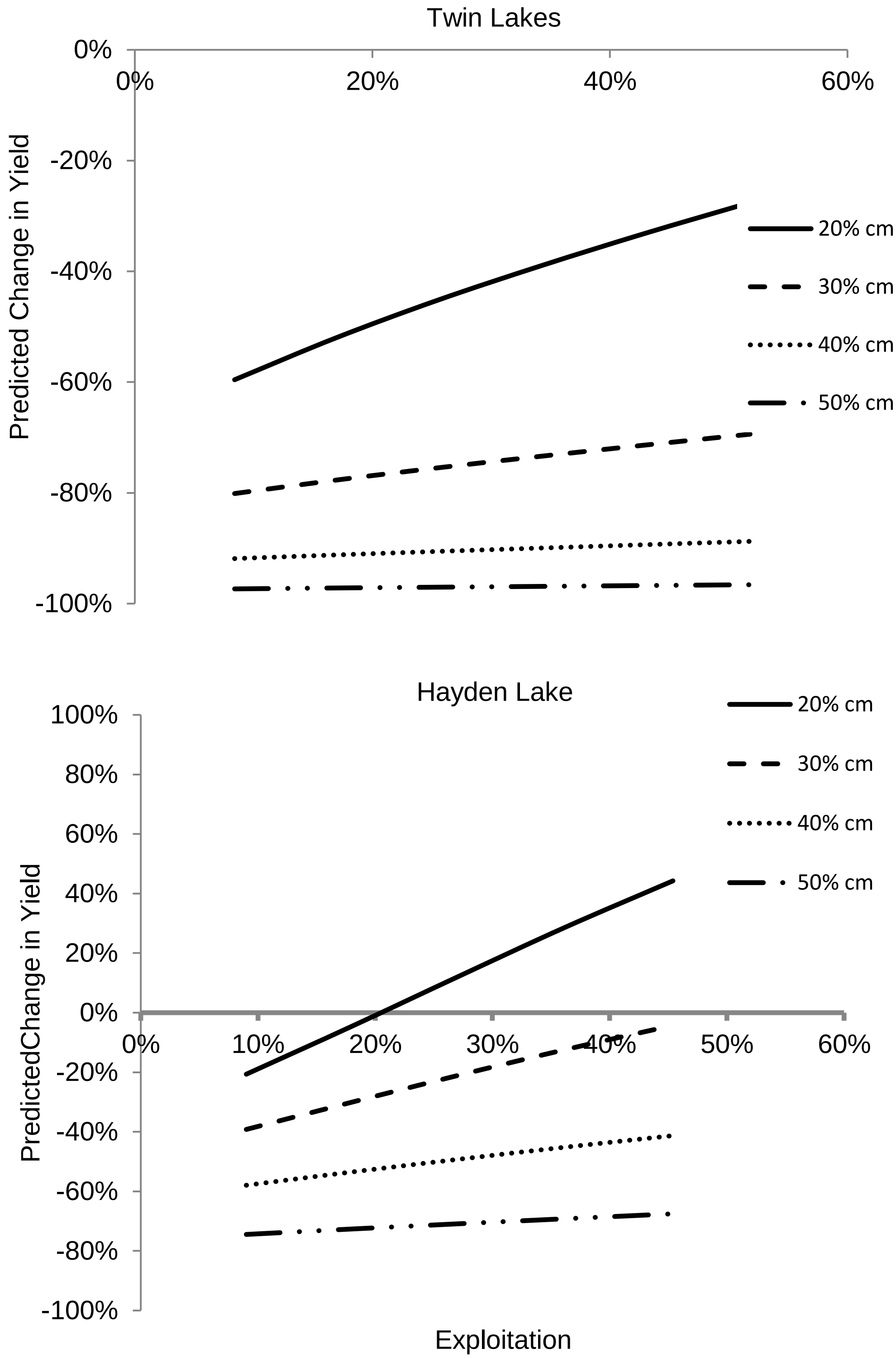

Figure 39. Predicted change in fishery yield of Black Crappie in Twin and Hayden lakes after applying a 250 mm minimum length limit. Yield was modeled over a range of explotation and varied by levels of conditional natural mortality (cm) from 20% to 50%.

HAYDEN AND PRIEST LAKES MYSIS SURVEYS

ABSTRACT

Mysis Shrimp *Mysis diluviana* were introduced into Pend Oreille, Hayden and Priest lakes with the objective of enhancing forage for existing fisheries. Both intended and unintended consequences resulted from these introductions. Recent declines in mysid abundance in Lake Pend Oreille prompted investigation of Hayden and Priest lake mysid abundance. We sampled Priest and Hayden lakes on May 28 and 29, 2014 to estimate lake wide mysid densities and found low densities. Mean total densities were 174 mysids/m^2 and 86 mysids/m^2 in Hayden and Priest lakes, respectively. Densities increased from 2013 estimates in Hayden Lake, but remained relatively stable in Priest Lake.

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INTRODUCTION

Mysis Shrimp *Mysis diluviana*, also commonly known as Opossum Shrimp, have been stocked around the globe in attempts to increase the forage base for sportfish. Mysids were introduced into Hayden Lake in 1974. Mysids were also introduced into Priest Lake and Lake Pend Oreille from 1965 to 1968 with the objective of benefiting the Kokanee *Oncorhynchus nerka* population.

In Hayden Lake, no adverse effects from shrimp have been described. Black Crappie *Pomoxis* n*igromaculatus*, Westslope Cutthroat Trout *Oncorhynchus clarki lewisi*, and Rainbow Trout *Oncorhynchus mykiss* are all known to consume mysids at some level. Though the impacts on fish growth have not been definitively assessed, they are generally thought to be positive with mysids considered a benefit to the fishery.

In Priest Lake, mysids were credited with increasing Kokanee growth (Irizarry 1974). However, the Kokanee fishery subsequently collapsed by 1976 possibly due to mysids enhancing the diet of smaller Lake Trout *Salvelinus namaycush*. The resulting Lake Trout fishery in Priest Lake largely replaced fisheries for kokanee and Westslope Cutthroat Trout (Liter et al. 2009). In recent years kokanee have demonstrated resurgence in abundance and an accompanied increasing interest by anglers (2014/2015 Priest Lake Angler Survey, see this report).

Mysids have not been routinely sampled in northern Idaho lakes. The exception to this has been Lake Pend Oreille, where a long history of monitoring has been completed. Annual sampling of Lake Pend Oreille showed a sharp decline in shrimp beginning in 2010 and through 2013 (Wahl et al. 2015). By 2012, mysid densities had declined by 98%. The collapse of mysids in Lake Pend Oreille, prompted an investigation of the densities of mysids in other northern Idaho lakes. Such declines in abundance could have major effects on the food web and the resulting sport fisheries. This chapter includes our data on mysid densities in Hayden and Priest lakes in 2014.

METHODS

We sampled mysid shrimp to estimate density in Priest and Hayden lakes on May 28 and 29, 2014, respectively. All sampling occurred at night during the dark phase of the moon. A total of twelve random sites were sampled on each water body. Vertical net tows were made from a depth of 46 m or the bottom, to the surface with a 1-m hoop net. We used a 1,000-micron mesh net with a 500-micron bucket. Area of the net's mouth was 0.8 m^2. Each mysid collected was counted, measured, and sexed. Young-of-the-year (YOY) mysids were classified as individuals under 10 mm. We calculated density as mysids per square meter based on the area of the nets mouth. We reported arithmetic mean density and 80% confidence intervals around each estimate.

RESULTS

Mysid density of all combined life stages in Hayden Lake was variable between sampled locations and ranged from 66 to 345 mysids/m^2 with a mean of 174 mysids/m^2 (± 32, 80% C.I.; Table 12). Young of the year (YOY) represented approximately 83% of the total sample and mean density of YOY was 144 mysids/m^2 (Table 13). Average density of immature and adult shrimp was 29 mysids/m^2. Sizes of immature and adult mysids were large and ranged from 17 to 26 mm (Figure 40).

Average density of mysids from all life stages in Priest Lake was estimated at 86 mysids/m^2 (± 28, 80% C.I.; Table 14). YOY represented approximately 38% of the total sample with a mean density of 32 mysids/m^2. Average density of immature and adult mysids was 53 mysids/m^2. Sizes of immature and adult mysids ranged from 13 to 21 mm (Figure 41).

Estimated mysid density from Hayden Lake represented minor increases from levels reported in 2013, but remained well below reported density in 2010 (Figure 42, Ryan et al. 2014, Maiolie et al. 2011). Density estimates from Priest Lake in 2013 and 2014 were similar, with overlapping confidence bounds around mean densities suggesting little changes occurred. (Figure 42, Ryan et al. 2014).

DISCUSSION

Our survey represented relatively new efforts to describe regional trends in mysid abundance. Although available data on mysids was limited, our data suggests densities in both Hayden and Priest lakes were low. Regionally, Lake Pend Oreille offers the only other Idaho water with available data for comparison of mysid densities and reported densities from that effort have typically been considerably greater than densities in our survey waters (Wahl et al. 2015). However, mysid densities declined dramatically between 2010 and 2013 in Lake Pend Oreille for unknown reasons (Wahl et al. 2015). We recommend continued monitoring of mysid abundance in Hayden and Priest lakes in an effort to describe the significance of the densities we observed. More specifically, do observed densities represent a population decline similar to that observed in Lake Pend Oreille. We also recommend periodic monitoring of fish communities in these waters to allow for better understand of the impact mysid densities have on regional fisheries.

MANAGEMENT RECOMMENDATIONS

1. Continue monitoring mysids in regional lakes

2. Complete periodic monitoring of fish communities in waters with mysids to better understand the impact of mysid densities on regional fisheries

Table 12. Densities of mysids (per m^2) collected from Hayden Lake on May 29, 2014. Densities were listed by location (UTM, zone 11, WGS84) and life stage (young of year (YOY), immature and adults).

Sample Site	E	N	YOY/m^2	Imm & Adult/m^2	All Ages/m^2
1	519004	5290006	231	26	257
2	519006	5289505	313	32	345
3	519511	5289996	142	29	171
4	519513	5289499	198	22	220
5	519997	5289615	197	32	229
6	520993	5290384	50	16	66
7	520998	5290009	88	20	108
8	521516	5289188	218	17	235
9	521999	5289374	98	56	154
10	522501	5290547	35	44	80
11	522494	5289510	99	26	125
12	523003	5291953	59	33	92

Table 13. Densities of mysids (per m2) collected from Hayden Lake on May 29, 2014. Densities were listed by location (UTM, zone 11, WGS84) and life stage (young of year (YOY), immature and adults).

Sample Site	E	N	YOY/m^2	Imm and Adult/m^2	All Ages/m^2
1	511020	5373027	20	42	61
2	509523	5374499	15	31	45
3	509011	5374995	12	31	43
4	507018	5377007	2	31	33
5	509017	5380011	126	73	199
6	510496	5380525	72	207	279
9	508520	5385066	54	31	84
10	510505	5387506	15	50	65
11	510523	5389997	33	61	94
12	509521	5391990	13	38	51
13	510021	5393000	7	11	18
14	511530	5396496	21	37	58

Table 14. Densities of mysids (per m2) collected from Priest Lake on May 28, 2014. Densities were listed by location (UTM, zone 11, WGS84) and life stage (young of year (YOY), immature and adults).

Sample Site	Z	E	N	Datum	YOY/m2	Immature and Adult/m2	All Ages/m2
1	11	519004	5290006	WGS84	231	26	257
2	11	519006	5289505	WGS84	313	32	345
3	11	519511	5289996	WGS84	142	29	171
4	11	519513	5289499	WGS84	198	22	220
5	11	519997	5289615	WGS84	197	32	229
6	11	520993	5290384	WGS84	50	16	66
7	11	520998	5290009	WGS84	88	20	108
8	11	521516	5289188	WGS84	218	17	235
9	11	521999	5289374	WGS84	98	56	154
10	11	522501	5290547	WGS84	35	44	80
11	11	522494	5289510	WGS84	99	26	125
12	11	523003	5291953	WGS84	59	33	92
Average					144	29	173

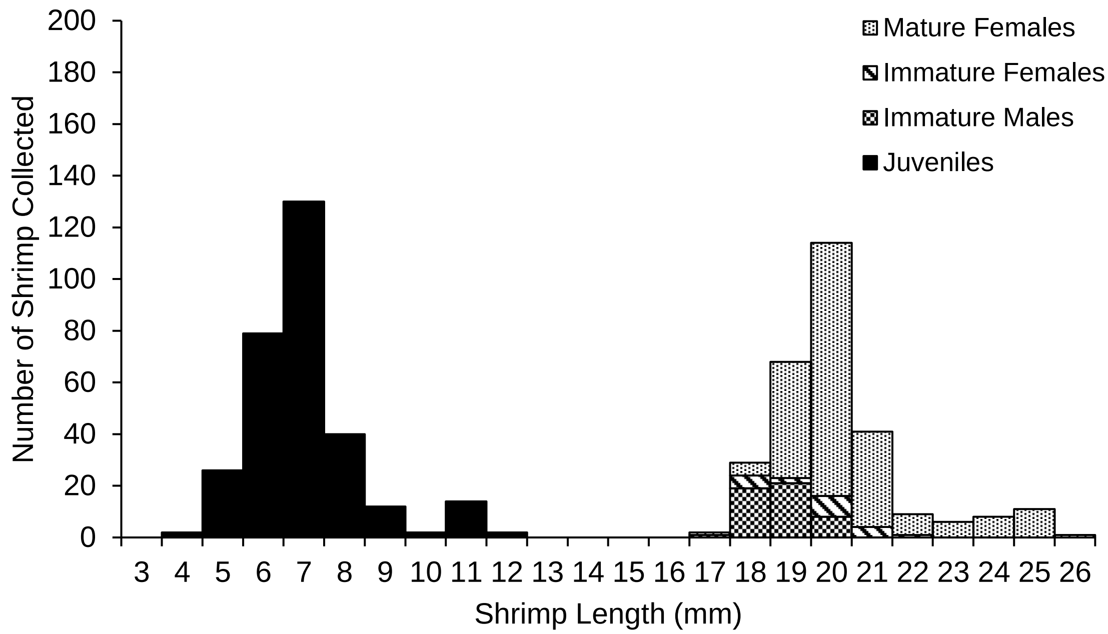

Figure 40. Length-frequency distribution of Mysis Shrimp collected from random locations in Hayden Lake, Idaho on May 29, 2014.

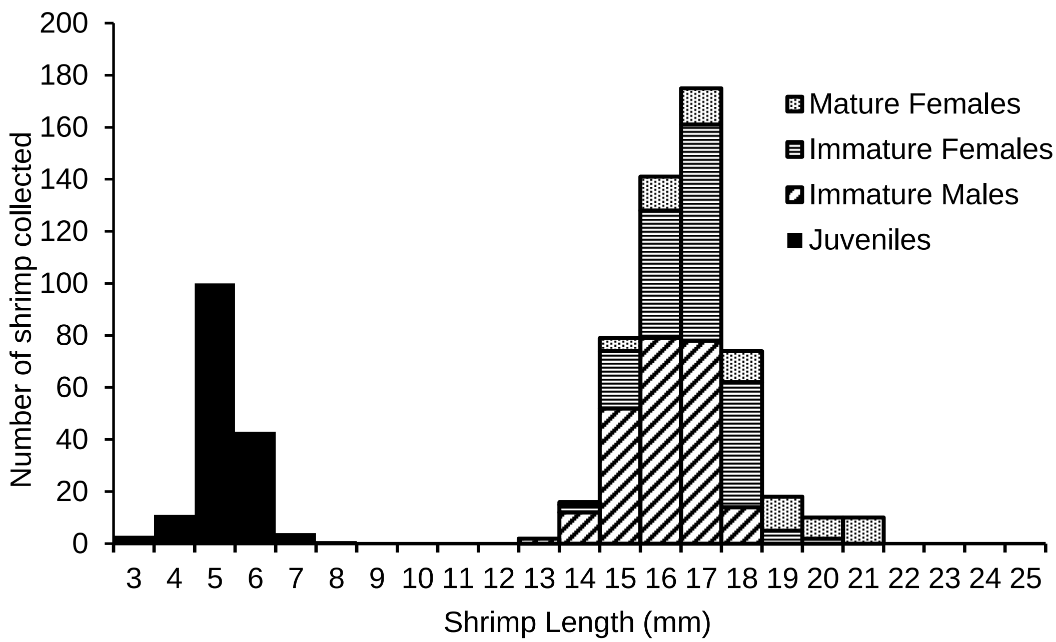

Figure 41. Length frequency distribution of Mysis Shrimp collected from random locations in Priest Lake, Idaho on May 28, 2014.

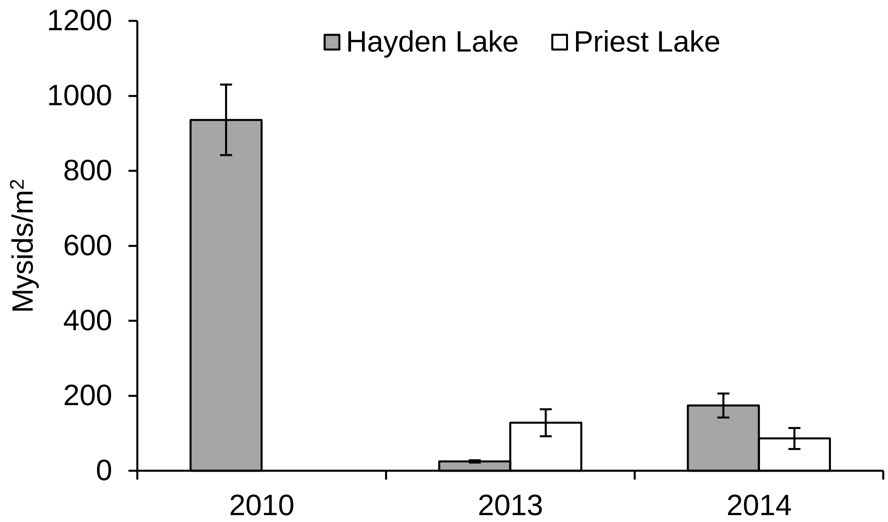

Figure 42. Estimated densities of mysids (per m^2) of all life stage (young of year, immature, and adults) from Hayden and Priest lakes in 2010, 2013 and 2014. Error bars represent 80% confidence intervals. No survey was completed on Priest Lake in 2010.

PANHANDLE REGION LOWLAND LAKE INVESTIGATIONS

ABSTRACT

Lowland lake surveys were conducted in Bonner and Smith Lakes in June 2014. Bonner Lake was last surveyed in 2004 followed by rotenone treatment in 2005 with the intent to remove illegally-introduced Northern Pike *Esox lucius.* The lake has not been surveyed since the rotenone project was completed. Smith Lake was last surveyed in 2005. Surveys were conducted to evaluate current fish community composition, effectiveness stocking efforts, and zooplankton quality and quantity. To do this, we used trap nets, gill nets and electrofishing as described in the Idaho Department of Fish and Game standard lowland lake sampling protocol. Fish were measured, weighed and aging structures were removed. In Bonner Lake, Largemouth Bass were the most abundant fish species, comprising 58% of the total catch by number and 59% of the catch by biomass. Proportional stock density (PSD) of Largemouth Bass was 2. Pumpkinseeds *Leopomis gibbosus,* Yellow Perch *Perca flavescens* and Rainbow Trout made up the rest of the catch and were less abundant. No Northern Pike were sampled in 2014. Largemouth Bass were also the most abundant species in Smith Lake, comprising 55% of the total catch in number and 32% of the catch by biomass. PSD of Smith Lake Largemouth Bass was 0. Rainbow Trout made up 37% of the total catch, and channel catfish comprised 8% of the catch. In Bonner Lake zooplankton biomass was low averaging 0.25 g/m among all sites. The zooplankton Ratio (ZPR) and Zooplankton Quality Index (ZQI) were estimated at 0.82 and 0.21, respectively. In Smith Lake zooplankton biomass was moderate averaging 0.45 g/m. ZPR and ZQI values were 0.62 and 0.50, respectively. Surveys in both lakes suggested a lack of forage species resulting in stunted Largemouth Bass populations. Development of a forage base may improve Largemouth Bass growth. Rainbow Trout stocking strategies appeared to be adequate based on abundance, growth rates and return to creel of stocked fish. Kokanee were not detected in either lake and we recommend further investigation of stocking effectiveness. Zooplankton quality was moderate and quantity was low in both Bonner and Smith Lakes.

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INTRODUCTION

The Idaho Department of Fish and Game (IDFG) provides diverse angling opportunities in lowland lakes To effectively manage these fisheries, lowland lake surveys are conducted periodically to assess the quality and composition of fish communities. In addition, multiple lowland lakes within the Panhandle region are routinely stocked to enhance fishing opportunities. Lowland lake surveys also provide a means of evaluating the current stocking rates and frequencies.

We surveyed Bonner and Smith Lakes in 2014 to evaluate the current fish communities and stocking strategies.

Bonner Lake

Bonner Lake is located in Boundary County, Idaho, 14 km east of Bonners Ferry, Idaho (Figure 43). The 9.7 ha lake has a mean depth of 6.7 m and a maximum depth of 18 m. Most of the land surrounding the lake is privately owned. IDFG maintains an access area on the west end of the lake consisting of a primitive boat ramp and outhouses. An IDFG restriction limits watercraft to “Electric Motors Only”.

Bonner Lake is managed as a mixed species fishery under general regional bag and possession limits. Rainbow Trout *Oncorhynchus mykiss* and Kokanee *Oncorhynchus nerka* are stocked annually in the lake. The lake was treated with rotenone in 2005 to remove Northern Pike *Esox lucius* and abundant small warm water fish. Past angler reports have indicated Northern Pike may have been caught in Bonner Lake since the 2005 chemical treatment. Bonner Lake was also chemically treated to remove fish in 1998, 1972, and 1955. Warmwater species were not restocked by IDFG following the 2005 treatment; however, Largemouth Bass *Micropterus salmoides*, Yellow Perch *Perca flavescens*, and Pumpkinseed *Lepomis gibbosus* are also present.

Smith Lake

Smith Lake is located approximately 8 kilometers north of Bonners Ferry, Idaho nestled in rolling, timbered hills (Figure 44). A USFS camping, picnic, and boat launch area with a fishing dock is available on the east side of the lake. Smith Lake is one of a series of small lakes located about 300 m above the Kootenai Valley floor at an elevation of 914 m. The lake has a surface area of 15.4 ha, a maximum depth of 11 m, and a mean depth of 6.7 m. The south end of the lake has a small area with extensive growths of aquatic vegetation while the remainder of the lake shoreline is mud or sand. An IDFG restriction limits watercraft to “Electric Motors Only”.

Smith Lake is managed as a mixed-species fishery under general regional bag and possession limits. Rainbow Trout, Kokanee and Channel Catfish *Ictalurus punctatus* are regularly stocked in the lake. Tiger Muskellunge *Esox masquinongy* × *Esox lucius* were mistakenly stocked in Smith Lake as advanced fingerlings (6 inches+) in 2013 (IDFG, unpublished data). We are uncertain how Tiger Musky may impact Smith Lake or if Tiger Musky survived at significant levels post out plant.

METHODS

We conducted lowland lake surveys on Bonner and Smith lakes in 2014 following the IDFG standard lowland lakes survey manual. In each lake, we set five trap nets, two floating and two sinking standard experimental gillnets and we electrofished the entire shoreline at night

(Figures 43 and 44). Gillnets and trap nets were set in Bonner Lake perpendicular to shore on June 10th and 11th in the evening and retrieved the following day (approximately 18 hours soak time). We electrofished Bonner Lake the night of June 10th. Nets were set in Smith Lake on June 16th and 17th and pulled the following morning (approximately 18 hours). We electrofished Smith Lake the night of June 16th. After capture, fish were identified, weighed (g) and measured to the nearest millimeter.

We collected otoliths from a representative sample of Largemouth Bass to estimate age. Otoliths were broken centrally on the transverse plane, browned, sanded on the broken surface, and viewed under a dissecting microscope using a fiber optic light to illuminate the broken surface. Length at age at time of capture of collected fish was reported as a measure of growth for Largemouth Bass. We collected scales from several larger Largemouth Bass to allow release of the larger fish. Scales were pressed on acetate slides and viewed on a microfiche reader. To avoid biases of scale accuracy in older individuals we limited our analysis of scales to a generalization of age, either greater than or less than 10 years of age. We also collected otoliths from Yellow Perch in Bonner Lake and used similar methods as was used for preparation and aging of Largemouth Bass otoliths. Length at age at time of capture was also used as a measure of growth for Yellow Perch.

We estimated catch per unit effort (CPUE) for electrofishing (fish/10 minute effort) and gill nets (fish/net) as measures of relative abundance. CPUE was not calculated for trap nets because very few fish were captured using this gear. To estimate total annual mortality of Largemouth Bass, we created an age-frequency histogram from log-transformed catch-at-age data and calculated a weighted catch-curve regression analysis using Fisheries Analyses and Simulation Tools (FAST; Slipke and Maceina 2000) software.

We evaluated population structure and fish condition within this survey effort and in comparison to previous surveys by estimating proportional stock densities (PSD; Anderson 1980) and relative weights (Anderson and Neumann 1996, Blackwell et al. 2000). Proportional stock density was estimated as:

$$\text{PSD} = \frac{\text{number of fish} \geq \text{qualitylength}}{\text{number of fish} \geq \text{stock length}} \times 100$$

Condition of fish was indexed using relative weight (W_r), represented by the equation:

$$W_r = (W / W_s) * 100$$

Where W is the weight of an individual fish and W_s is a length-specific standard weight resultant of a weight: length regression representative of the species:

$$\log_{10}(W_s) = a' + b * \log_{10}(L)$$

Where a′ is the intercept and b is the slope and L is the total length of the individual fish. Mean W_r values of 100 indicate ecological and physiological optimals (Anderson and Neumann 1996, Blackwell et al. 2000).

We also sampled zooplankton in Bonner and Smith lakes to evaluate the quality and quantity of available forage for planktivorous fishes. Zooplankton samples were collected on August 19th from three randomly selected locations distributed throughout the lake. Zooplankton were collected using three nets fitted with small (153µm), medium (500µm) and large (750µm) mesh. Nets were lowered to the bottom for each tow. Samples were preserved in denatured ethyl alcohol and were processed using methods described by Teuscher (1999). We used the zooplankton ratio method (ZPR) and the zooplankton quality index (ZQI) to assess zooplankton availability (Teuscher 1999).

RESULTS

Bonner Lake

Bonner Lake contained a relatively simple fish community. We captured four species including Largemouth Bass, Pumpkinseed, Yellow Perch, and hatchery Rainbow Trout (Table 15). Electrofishing was the most efficient capture method and collected 85% of the total fish collected (Table 15; Table 16). Gill nets collected 12% of the fish and trap nets collected 2% of the fish (Table 15). No Northern Pike were collected.

Largemouth Bass catch rates were high and similar to previous surveys, representing the most abundant species caught in our survey (electrofishing CPUE 52.6; Table 15; Table 18). Largemouth Bass made up 58% of the total catch by number and 59% of the catch by biomass (Table 15). We captured eight Largemouth Bass ranging in lengths from 399-530 mm. Age of these eight large fish was estimated using scales and all were assessed to be greater than ten years of age. Given their age, it was likely these fish represented a stocking event after the 2005 rotenone treatment and growth rates may not reflect the true condition of Bonner Lake. Therefore, these fish were removed from further analysis to avoid misrepresentation of average growth conditions in the lake. Remaining Largemouth Bass lengths ranged from 54 to 307 mm and averaged 146 mm (SE = 3.32; Table 16; Figure 45). Ages ranged from 1 to 11 years old (Figure 46). Largemouth Bass growth was very slow and fish within our sample did not reach 300 mm (12 inches) until age 11 (Figure 47). Proportional size distribution of Largemouth Bass was low at 2 and condition indexed by mean relative weight was 92 (SE = 0.72). Relative weight values for sub-stock (150-200 mm) and stock (200-300 mm) length fish were 92. Relative weight increased with size at 110 for quality size fish (300-380 mm) (Figure 48). Recruitment appeared consistent; however strong and weak year classes were present. Total annual mortality rate was estimated at 27.2% (Figure 46).

Pumpkinseed were the second most abundant fish species and comprised 29% of the total catch by number and 12% of the catch by biomass (electrofishing CPUE = 25.8 gill net CPUE = 1.5, Table 15). Pumpkinseeds lengths ranged from 42 to 193 mm and mean length was 121 mm (SE = 5.9).

Yellow Perch were collected in low abundance and represented 6% of our sample by number and by biomass (electrofishing CPUE = 4.2; gill net CPUE = 2.3; Table 15). Lengths ranged from 164 to 252 mm and mean length was 198 mm (SE = 3.57; Figure 49). Yellow Perch ages ranged from 3 to 5 years old and mean length at age at the time of capture for age-3 fish was 172 mm, 195 mm for age-4 fish, and 240 mm for age-5 fish. PSD of Yellow Perch was 39, while condition was similar and below average for all size classes with a mean W_r of 82 (SE = 1.07).

Rainbow Trout represented 6% of the total catch (electrofishing CPUE = 0.2, gill net CPUE = 7) by number and 22% of the total catch by biomass (Table 15). Mean length of Rainbow Trout was 321 mm (SE = 8.59) and lengths ranged from 248 to 410 mm. Fifty seven percent of the fish collected (n = 16) were larger than 305 mm.

Kokanee *Oncorynchus nerka* were not detected in our sampling despite previous stocking in Bonner Lake.

Zooplankton biomass was low averaging 0.25 g/m among all sites. ZPR and ZQI were estimated at 0.82 and 0.21, respectively.

Smith Lake

Smith Lake also contained a simple fish community. We collected three species including Largemouth Bass, Rainbow Trout and Channel Catfish. Similar to previous surveys, Largemouth Bass were the most abundant species comprising 55% of the total catch by number and 32% of the catch by biomass (electrofishing CPUE = 34.3; Table 15; Table 19). Mean length of Largemouth Bass captured was 204 mm with lengths ranging from 74 to 267 mm (SE = 2.31; Table 17; Figure 50). Largemouth Bass PSD was 0. Condition as indexed by mean relative weight (W_r) was 95. Relative weight declined with size at 106 (SE=0.96) for sub-stock fish and 91 (SE = 0.55; Figure 51) for stock size fish. Ages ranged from 1 to 12 years old (Figure 52). Growth of Largemouth Bass was also slow in Smith Lake as fish did not reach 300 mm (12 inches) until 12+ years of age (Figure 53). Recruitment was fairly consistent; however, strong and weak year classes were present. Total annual mortality was estimated at 18.2% (Figure 52).

Rainbow Trout were the second most abundant fish species in our sample and represented 37% of the total catch by number and 43% of the catch by biomass (Table 15). Electrofishing (CPUE = 18.3) resulted in higher catch rates than gill nets (CPUE = 11.3) for Rainbow Trout (Table 15). Rainbow Trout lengths ranged from 223 to 390 mm and mean length was 277 mm (SE = 2.46). Fourteen percent (n = 24) of Rainbow Trout collected were greater than 305 mm.

Channel Catfish were the least abundant species and comprised 8% of the catch by number and 25% of the catch by biomass (Table 15). Catch-per-unit-effort for Channel Catfish was 4.3 for electrofishing and two for gill nets (Table 15). Channel catfish condition as indexed by mean relative weight (W_r) was high at 109 (SE = 2.66). Mean length of channel catfish captured was 406 mm (SE=4.83) and lengths ranged from 341 to 464 mm.

Our sampling efforts failed to detect any Tiger Muskellunge.

Zooplankton biomass was low averaging 0.45 g/m among two of the three sample locations. Samples from one of the three sample sites were removed from analysis because they contained large quantities of sediment from net contact with the lake bottom. ZPR and ZQI values were 0.62 and 0.50, respectively.

DISCUSSION

Bonner Lake

The fish community in Bonner Lake has changed little since the last survey in 2004 even though the lake had been chemically treated in 2005 (Liter and Horner 2008). Largemouth Bass and Pumpkinseed were the dominant species in both 2004 and 2014 surveys. Length ranges for these species were similar in both survey collections. Although similar in most respects, the previous survey did not detect Yellow Perch as in our 2014 effort. Prior to this study, Bonner Lake had been treated with rotenone on four separate occasions all with the same intent of removing small or stunted Largemouth Bass and other warm water species. Bonner Lake has remained in an unbalanced state with a high proportion of slow growing predators and low proportion of prey despite removal efforts. Balanced populations typically contain a high proportion of prey and a low proportion of predators where the prey base provides enough forage to allow for sufficient growth of predators (Swingle 1950).

Largemouth Bass in Bonner showed evidence of stunting. Fish were very abundant, but were small and slow growing. Northern Idaho Largemouth Bass typically grow to 305 mm in approximately five to six years (Dillon 1990), while fish in our sample took over 11 years to reach a similar size. Although slow growth was the typical pattern in Bonner Lake Largemouth Bass, we collected eight large fish (>16 inches), which likely represented a more rapid growth pattern. Analysis of length and age (by scales) suggested the eight large fish were greater than ten years of age and suggested these fish were older than the rotenone project completed in 2005. Although no IDFG stocking record was found indicating Largemouth Bass were stocked in Bonner Lake, it seems likely these large faster growing fish had not grown in Bonner Lake under the same conditions as the majority of sampled bass. The remainder of Largemouth Bass collected, exhibited slower growth patterns and were likely subsequent progeny of any stocked fish or survivors of the rotenone treatment.

We recommend some consideration be given to reducing Largemouth Bass abundance and increasing the forage base to increase growth rates of Largemouth Bass in Bonner Lake. Although abundant stunted populations of Largemouth Bass provide good harvest opportunities, low annual mortality of the Bonner Lake population suggested anglers are exploiting this population only at very low rates if at all. Providing a larger average fish (i.e. greater than stock size) could increase angler interest in this fishery. We recommend abundance in Bonner Lake be reduced by direct removal and forage be supplemented by introducing an additional prey species. We suggest Bluegill as a prey species for supplementation.

Although, manipulation of Bonner Lake predatory prey balances has potential to improve Largemouth Bass growth rates, it may be prudent to first observe other regional fisheries with similar bass Bluegill communities as reference populations prior to new species introductions in Bonner Lake. Brush Lake, located approximately 16 miles northwest of Bonner Lake, was reported to have a similar Largemouth Bass population and also supports a quality Bluegill fishery (Liter et al. 2008). Prior to manipulating predator-prey balances in Bonner Lake, we recommend surveying Brush Lake as a reference water to evaluate management alternatives where Bluegill already exist.

Yellow Perch were present in very low abundance in Bonner Lake, but represented a good PSD value. Anderson and Weithman (1978) reported PSD values of 30-60 were acceptable for balanced populations of Yellow Perch. Conversely, Perch were in poor condition which may indicate lack of suitable forage. Interspecific competition may also be occurring because of the overabundant Largemouth Bass population. Yellow Perch in Bonner Lake demonstrated slow growth rates, reaching 200 mm at four to five years of age. Yellow Perch in the Pend Oreille River, Idaho reached 200 mm in length in approximately two to three years (see Pend Oreille Fall Walleye Index Netting in this report).

Rainbow Trout greater than 305 mm made up a large portion of the trout collected in Bonner Lake and suggested carryover of stocked fish is common. Rainbow Trout were stocked in Bonner Lake in late April 2014 prior to our survey at a mean length of approximately 257 mm (IDFG, unpublished data). Although, we anticipated some growth of these fish occurred prior to our survey it was unlikely those fish grew beyond 305 mm in the 48 days post stocking. Rainbow Trout stocking occurred in April, May, and June 2013 with average fish lengths ranging between 239 and 241 mm. We recommend continuing the current stocking rate of catchable-sized Rainbow Trout catchables which appears to be working to provide good catch rates.

No Kokanee were collected during our sampling efforts in 2014 despite stocking efforts. Kokanee were stocked for the first time in 2011 as fry and then in 2012 as fingerlings. Kokanee stocking success and survival in Bonner Lake is unknown but may be influenced by Largemouth Bass predation, especially because bass are overabundant and fish forage is lacking. Our failure to detect kokanee may also reflect our gear efficiency during the survey. Gill nets were oriented to the shoreline. Kokanee likely occupied more pelagic waters during our survey. As such, catchability of kokanee may have been reduced. Kokanee fry were also stocked in the spring of 2014 but would not have been recruited to our gear at the time of sampling. We recommend further evaluation of kokanee recruitment from supplementation to determine the value of these stocking efforts. Evaluation could include suspended pelagic gill netting during early summer after stratification, or angler interviews to determine return to the creel.

Quality and quantity of zooplankton in Bonner Lake has declined from observed conditions in 2010 (Maiolie et al. 2011). Estimated biomass declined dramatically (> 1.0 g/m) as did ZQI values (> 0.6), suggesting both a reduction in abundance and availability of large preferred zooplankton. ZPR values also demonstrated a reduced proportion of preferred-sized zooplankton (> 0.3). It is not clear what may have initiated large shifts in zooplankton abundance. We speculate that shifts in zooplankton abundance may reflect increasing densities in the fish community. No evaluation of fish abundance was available between the 2005 chemical treatment of Bonner Lake and present. However, it is likely abundance of warmwater fishes has increased progressively with each additional age class. As noted in this report, relative abundance of Largemouth Bass and Pumpkinseed was high in our survey. Rainbow Trout abundance has likely changed little, as abundance is driven by stocking rates which have remained constant. It may also be possible that zooplankton samples were compromised by sediment intrusion. Some sediment was captured in one sample during this evaluation and limited analysis to two sample sites. We recommend resampling zooplankton in following years to confirm the precision of our results.

Smith Lake

The Smith Lake fish community also changed little since the last reported sampling event in 2005 (Liter et al. 2008). We detected Largemouth Bass, Channel Catfish, and Rainbow Trout. We did not detect Brown Bullheads *Ictalurus nebulosus* which were reported in the 2005 survey. Structure of the population was also similar between the two surveys. Channel Catfish were consistently abundant and in good condition. Largemouth Bass have remained abundant with moderate condition, especially for larger fish (>200 mm). Growth rates of Largemouth Bass, although not evaluated in 2005, were likely similar between surveys with no fish reaching over 305 mm.

Similar to Bonner Lake, growth and mortality of Smith Lake Largemouth Bass suggested population stunting and low angler exploitation. Slow growth of Largemouth Bass was likely due to a combination of high abundance and lack of available forage. No typical forage species were detected in our survey. Our interpretation of existing population dynamics contradicted previous conclusions from 2005 (Liter et al. 2008). In that survey, Largemouth Bass greater than 305 mm was assumed to be cropped from the population by anglers. It was unlikely angling mortality played a role in the current population that we observed, based on low annual mortality. We failed to detect any Largemouth Bass greater than 267 mm despite 35% of our sample being estimated at ages between seven and twelve years old. We recommend consideration be given to adjusting predator-prey balances in Smith Lake to improve growth rates of Largemouth Bass as recommended for Bonner Lake in this report.

Carryover of stocked Rainbow Trout from 2013 out plants was evident in Smith Lake. Similar to Bonner Lake, Rainbow Trout greater than 305 mm were present in our sample. Fish stocked in 2014 were not anticipated to be larger than 305 mm at the time of our survey. Although the proportion of Rainbow Trout greater than 305 mm was less than that observed in Bonner Lake, by number catches were similar. Given we sampled both lakes with the same sampling effort, carryover rates are likely similar as well. Our survey on Smith Lake followed a June stocking event that likely increased the proportion of Rainbow Trout less than 305 mm in our sample. Angler exploitation of stocked Rainbow Trout in Smith Lake has been estimated at 32%, representing relatively good return of stocked fish (Fredericks et al. 2013). We recommend continued stocking of Rainbow Trout catchables at rates that maximize return to the creel.

Kokanee have been stocked periodically in Smith Lake since 1981 as either fry or fingerlings. However none were detected in surveys in either 2005 or 2014 (Liter et al. 2008). Similar to Bonner Lake, Kokanee abundance may have been influenced by Largemouth Bass predation and or recruitment to our sampling gear. We recommend further evaluation of kokanee recruitment from supplementation to determine the value of these stocking efforts. Evaluation could include targeted gill netting during early spring months or targeted angler contacts to determine return to the creel.

Zooplankton samples from Smith Lake suggested a moderate proportion of the available zooplankton were of preferred size for planktivorous fishes (e.g. Rainbow Trout), but that zooplankton quantity has declined from a previous 2010 survey (Maiolie et al. 2011). We observed ZPR values changed little from 2011 results, but declining ZQI values corresponded with large declines in zooplankton biomass. As with observed changes in Bonner Lake, we are uncertain as to the cause of shifts in zooplankton quantity. We recommend resampling zooplankton in following years to confirm precision of our results.

MANAGEMENT RECOMMENDATIONS

1. Survey Brush Lake in Boundary County to provide a reference of bass-Bluegill communities and management alternatives prior to manipulating fish communities in either Bonner or Smith lakes.

2. Consider reducing Largemouth Bass abundance through direct removal while increasing forage abundance through supplementation to increase growth rates in Bonner and Smith Lake. Consider introducing mature Bluegill to establish a forage base.

3. Continue current Rainbow Trout stocking rates and frequencies in both Bonner and Smith lakes and of Channel Catfish in Smith Lake

4. Further evaluate Kokanee stocking to determine the value of current efforts. Evaluation could include targeted gill netting during early spring months or targeted angler contacts to determine return to the creel.

5. We recommend resampling zooplankton in following years to confirm precision of reported ZPR and ZQI.

Table 15. Catch (*n*), catch-per-unit-effort (CPUE; fish/h), and 80% confidence intervals (in parentheses) for species collected from Bonner and Smith Lakes using electrofishing, gill nets, and trap nets in June 2014.

Bonner Lake

Species	*n*	% of Catch	Electrofishing	Gill net	Trap net
Largemouth Bass	283	58	52.6 (8.3)	4.75 (1.2)	0.2 (NA)
Pumpkinseed	143	29	25.8 (10.5)	0.75 (0.5)	2.2 (1.6)
Rainbow Trout	29	6	0.2 (NA)	7 (3.7)	0
Yellow Perch	31	6	4.4 (2.7)	2.25 (2.3)	0

Smith Lake

Species	n	% of Catch	Electrofishing	Gill net	Trap net
Largemouth Bass	254	55	34.3 (6.0)	3.5 (2.0)	0
Rainbow Trout	173	37	18.3 (9.1)	11.3 (6.8)	0
Channel Catfish	38	8	4.3 (1.8)	2.0 (1.0	0

Table 16. Mean, minimum and maximum total length (TL) and weight (Wt; g) by species for fish captured with combined gear types from Bonner Lake in June 2014.

Species	Mean TL (mm)	Min TL (mm)	Max TL (mm)	Min Wt (g)	Max Wt (g)
Largemouth Bass	154	54	530	1	2,800
Pumpkinseed	122	42	193	3	133
Rainbow Trout	321	248	410	130	747
Yellow Perch	198	164	252	49	196

Table 17. Average (Avg TL), minimum (Min TL), and maximum (Max TL) total lengths and minimum (Min Wt) and maximum (Max Wt) weights by species for fish captured with combined gear types from Smith Lake in June 2014.

Species	Avg TL (mm)	Min TL (mm)	Max TL (mm)	Min Wt (g)	Max Wt (g)
Largemouth Bass	204	74	267	6	244
Rainbow Trout	276	132	390	95	511
Channel Catfish	406	341	464	373	1047

Table 18. Percent of catch (% of Catch), mean length, Proportional Stock Density (PSD), and mean condition (W_r) for warm water fish species collected during previous lowland lake surveys in Bonner Lake.

	% of Catch	Mean length (mm)	PSD	W_r
		1996		
Largemouth Bass	64		45	98.9
Pumpkinseed	25		4.7	
		2004		
Largemouth Bass	52	144		
Pumpkinseed	44	108		
		2014		
Largemouth Bass	58	154	2	92
Pumpkinseed	29	122		
Yellow Perch	6	198	39	82

Table 19. Percent of catch (% of Catch), mean length, Proportional Stock Density (PSD), and mean condition (W_r) for warm water fish species collected during previous lowland lake surveys in Smith Lake.

	% of Catch	Mean Length (mm)	PSD	W_r
		1983		
Largemouth Bass	13	185		
Brown Bullhead	57	204		
		1990		
Largemouth Bass	85	229	2	104
Brown Bullhead	<1			
		2005		
Largemouth Bass	80	198	0	96-144
Channel Catfish	<1		4.7	
Brown Bullhead	<1			
		2014		
Largemouth Bass	55	204	0	95
Channel Catfish	8	406		109

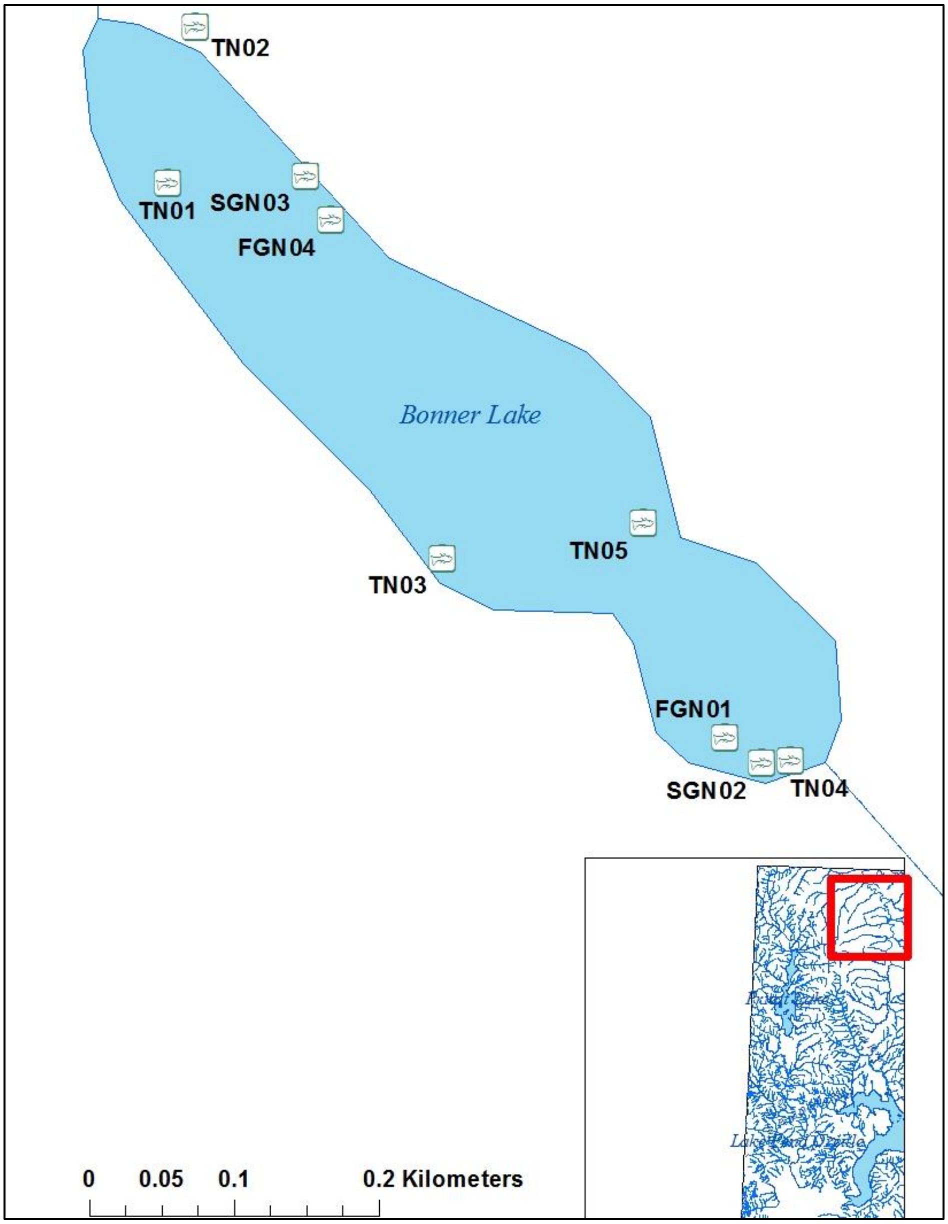

Figure 43. Locations of gill nets and trap nets during a lowland lake survey of Bonner Lake, Idaho in June 2014.

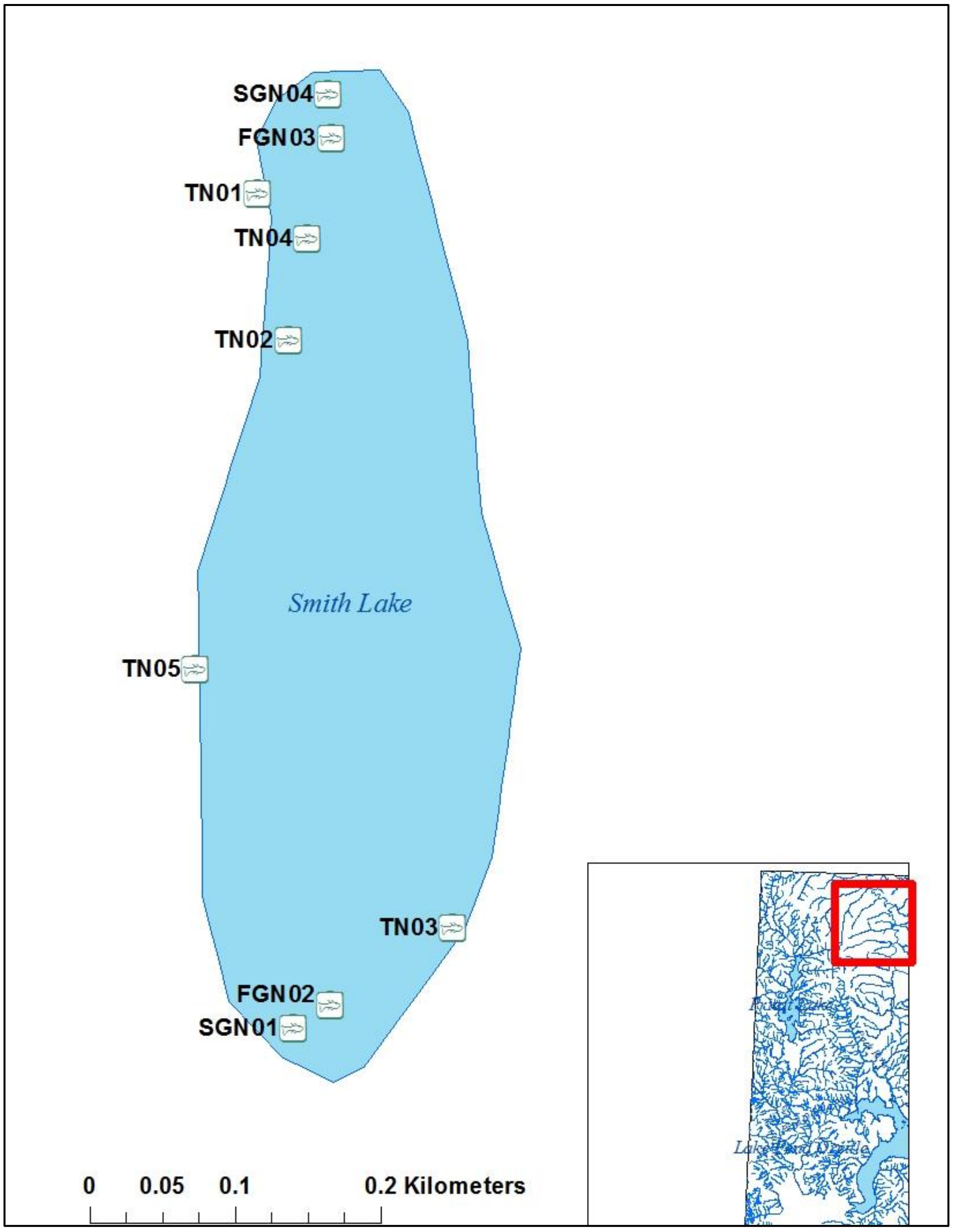

Figure 44. Locations of gill nets and trap nets during a lowland lake survey of Smith Lake, Idaho in June 2014.

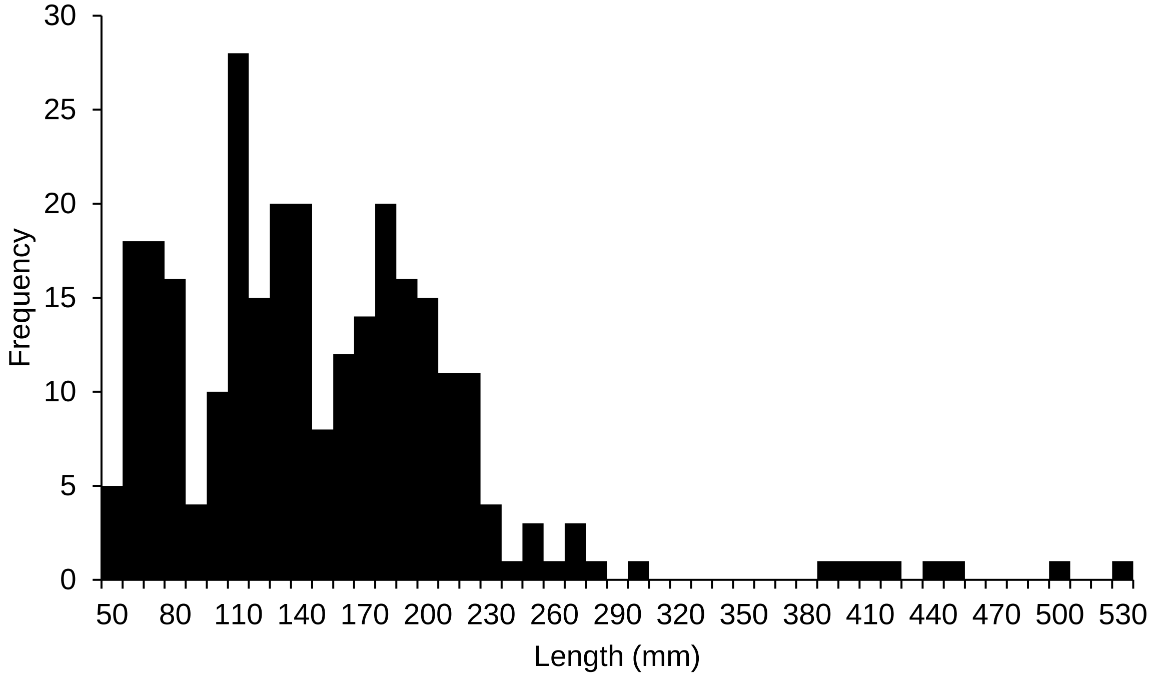

Figure 45. Length-frequency distribution of Largemouth Bass collected via boat electrofishing, gill nets, and trap nets from Bonner Lake on June 10–11, 2014.

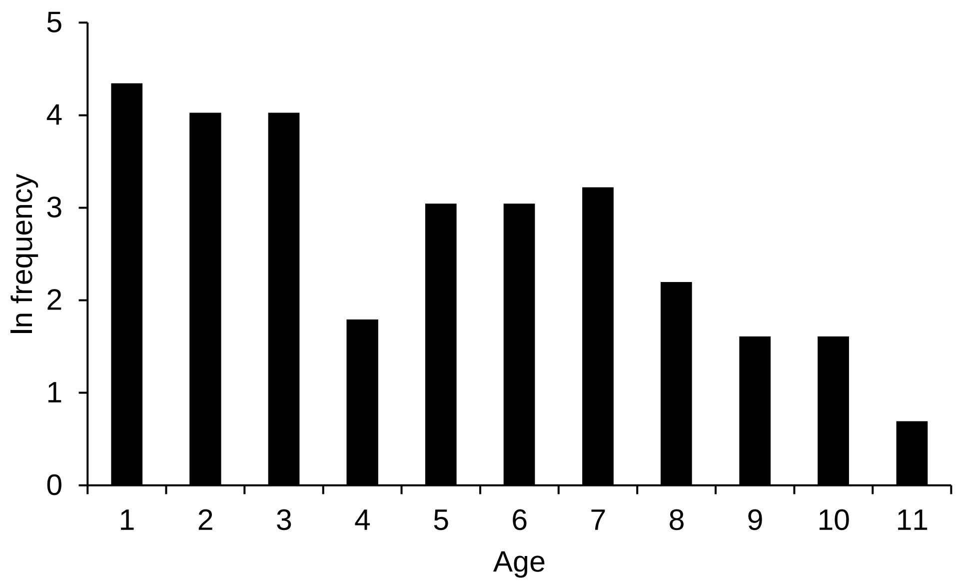

Figure 46. Age frequency of Largemouth Bass collected via electrofishing from Bonner Lake in June 2014.

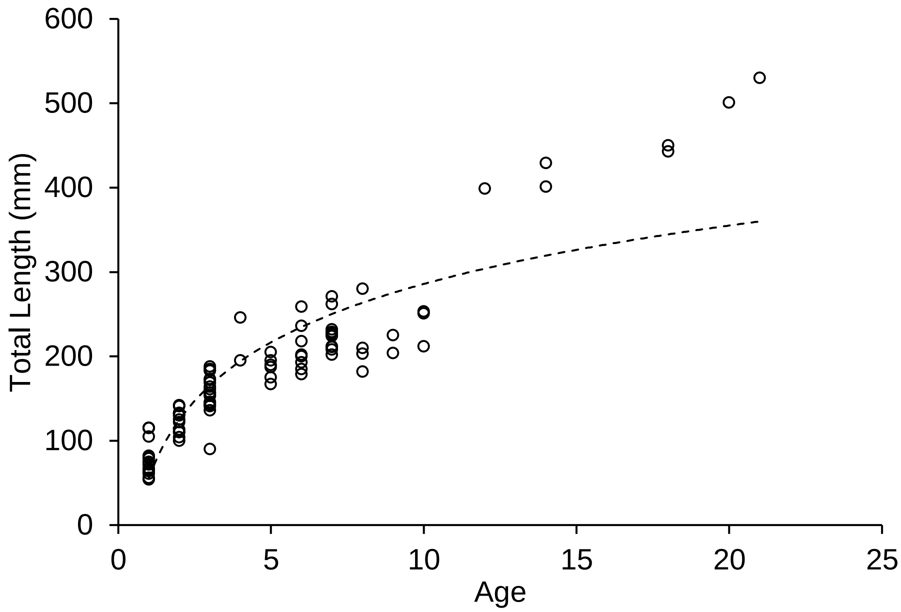

Figure 47. Length at age of Largemouth Bass collected via electrofishing from Bonner Lake June 2014.

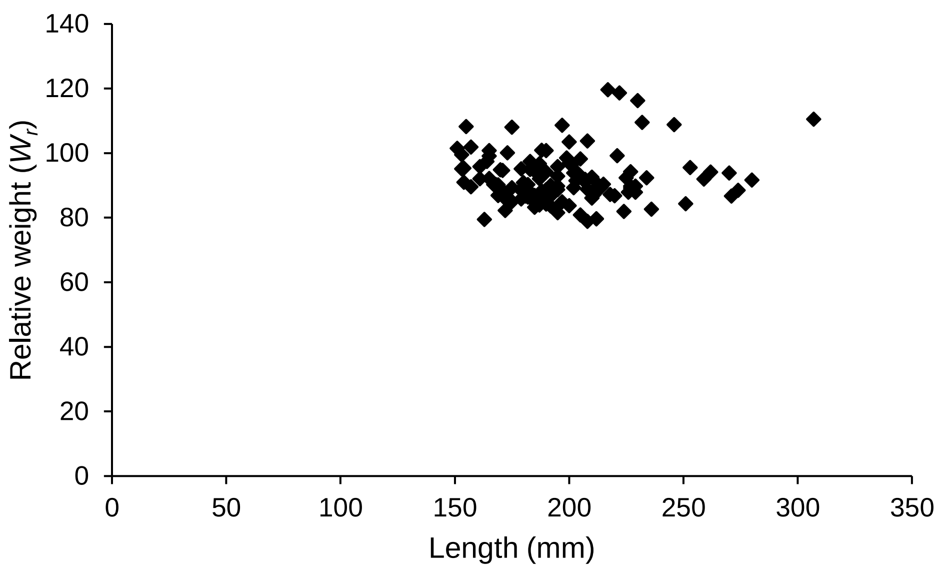

Figure 48. Largemouth Bass condition as indexed by relative weight (W_r) for fish >150 mm collected from Bonner Lake on June 10–11, 2014.

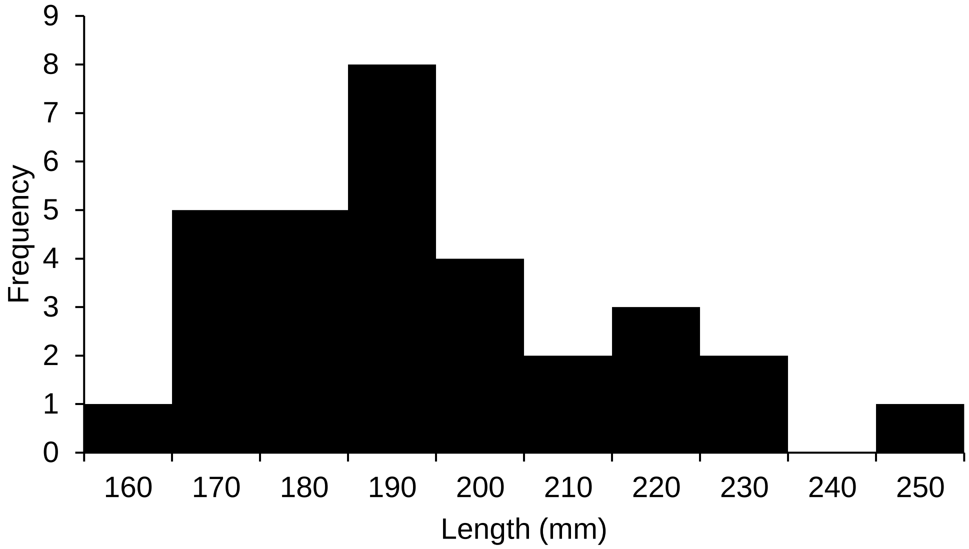

Figure 49. Length-frequency distribution of Yellow Perch collected from Bonner Lake via boat electrofishing and gill nets on June 10–11, 2014.

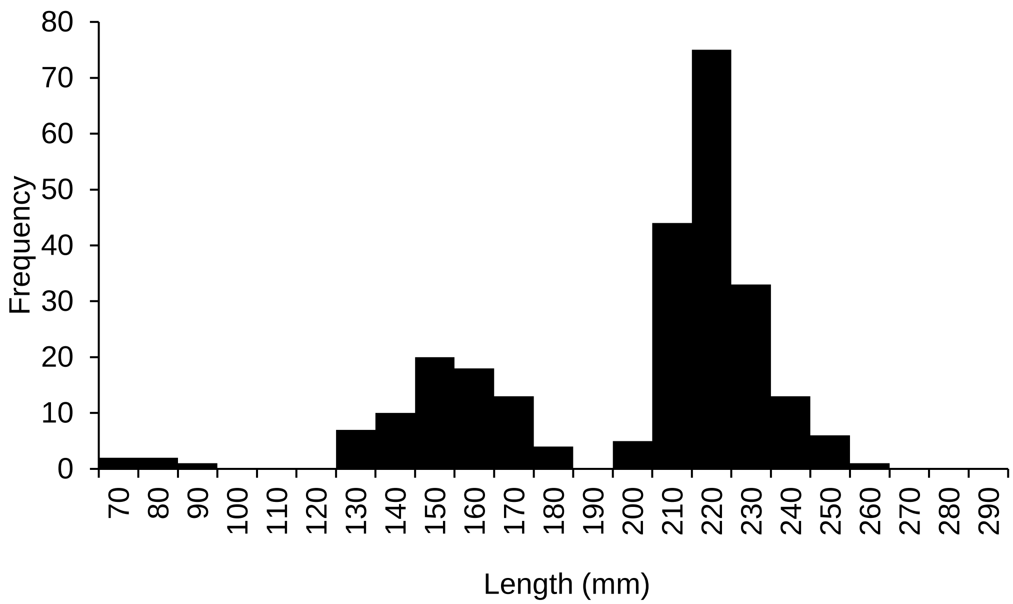

Figure 50. Length-frequency distribution of Largemouth Bass collected via boat electrofishing, gill nets, and trap nets from Smith Lake on June 16–17, 2014.

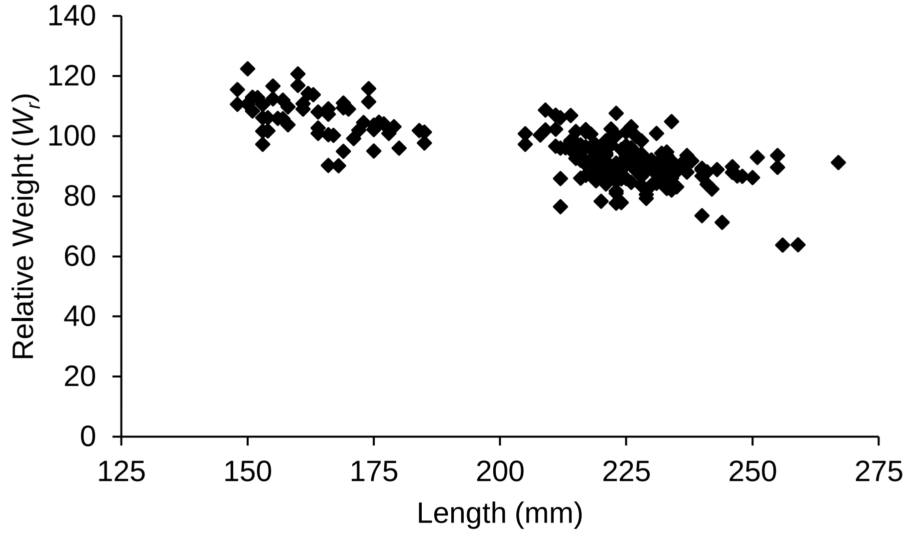

Figure 51. Largemouth Bass condition as indexed by relative weight (W_r) for fish >150 mm collected from Smith Lake on June 16–17, 2014.

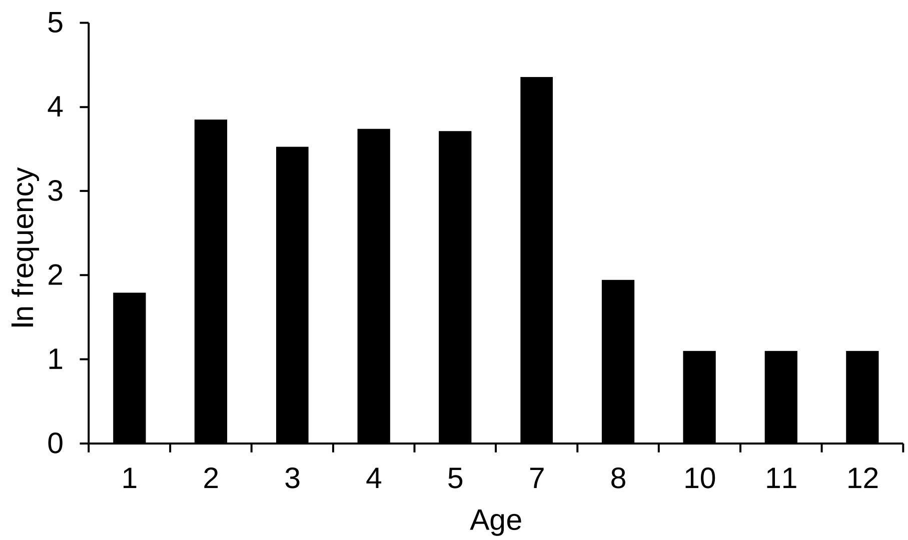

Figure 52. Age frequency of Largemouth Bass collected via electrofishing from Smith Lake in June 2014.

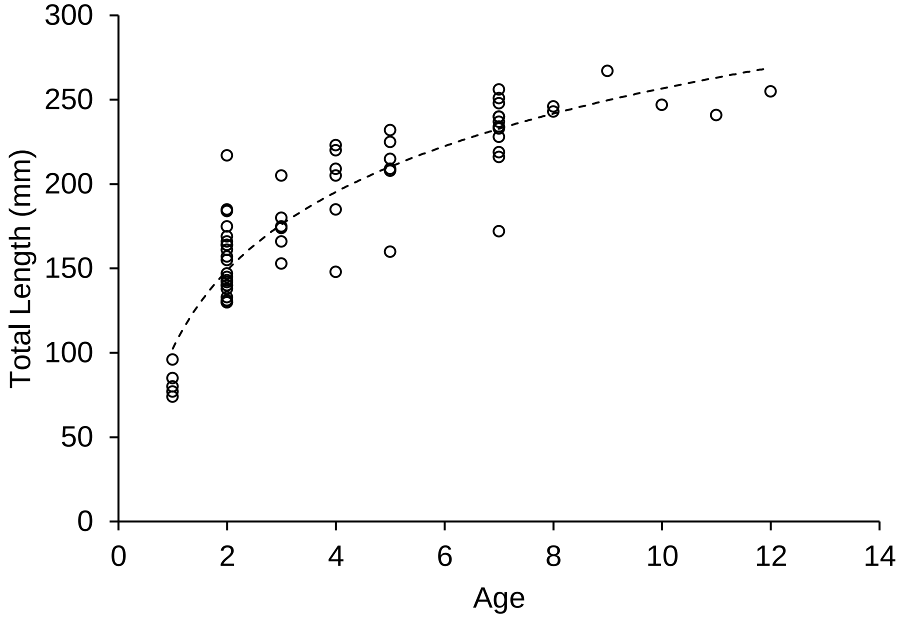

Figure 53. Length at age of Largemouth Bass collected via electrofishing and gill nets from Smith Lake in June 2014.

PEND OREILLE WALLEYE MONITORING 2014

ABSTRACT

Non-native fish colonization has been recognized as a threat to native fish communities across the west and specifically in the Pend Oreille drainage. Walleye, a non-native fish in the Pend Oreille basin, were first documented in this system during a fishery survey of the Pend Oreille River (POR) in 2005. The presence of Walleye in this system and the potential impact of Walleye on existing fish communities concerns fisheries managers. As such, monitoring of Walleye abundance and distribution in Lake Pend Oreille (LPO) and the POR has been important as tool for better understanding current population status. In 2011, a comprehensive fall Walleye index survey was completed to better describe the current condition of the population. We continued monitoring efforts in 2014 by surveying the Walleye population using standardized Fall Walleye Index Netting (FWIN) protocols. We completed 48 net nights among all sampled areas resulting in a total capture of 105 Walleye and a catch rate of 2.2 ± 0.5 Walleye per net. Walleye captures were well distributed. Eight age classes were present in the collected samples. Survey results suggested Walleye were present in low, but increasing abundance. Pend Oreille basin Walleye continue to demonstrate characteristics such as fast growth, good condition, and early maturation consistent with an expanding population. However, results suggested dynamic rates have moderated since the last survey. We also described basic population dynamics of Yellow Perch collected incidentally in association with Walleye surveys. We found Yellow Perch grew to 200 mm within approximately three years. Multiple Yellow Perch age classes were present, but 87% of the fish collected were from one year class. Results suggested Yellow Perch were not stunted, but exhibited cyclic recruitment that may impact fishing conditions from year to year. Continued monitoring of long term trends in Walleye abundance and distribution in the Pend Oreille basin is recommended as a means of understanding future effects to other Pend Oreille basin fishes. We also recommend continued monitoring of Yellow Perch in association with future FWIN surveys to help confirm the mechanisms at work that influence the presence of quality fish in the fishery.

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INTRODUCTION

Non-native fish colonization has been recognized as a threat to native fish communities across the west and specifically in the Pend Oreille drainage (PBTAT 1998). Walleye *Sander vitreus* have been known to negatively impact salmonid fish assemblages where these populations overlap (Baldwin et al. 2003). Lake Trout in Lake Pend Oreille (LPO) are heavily studied and currently being suppressed in an effort to enhance kokanee *Oncorhynchus nerka* and associated native fish assemblages. Walleye are also present in LPO, but little is known about their abundance, distribution, and associated impacts on the fish community.

Walleye are not native to the Pend Oreille basin and were first documented in the system during a fishery survey of the Pend Oreille River (POR) in 2005 (Schoby et al. 2007). Subsequently, Walleye were also documented in LPO near the Pack River between 2007 and 2010 (IDFG, unpublished data). Walleye were illegally established in the upstream waters of the lower Clark Fork River within the Noxon Reservoir reach in the early 1990s and continue to persist (Horn et al. 2009). This upstream population is believed to be the source of primary introduction into LPO and the POR.

In addition to documenting the presence of Walleye in 2007, LPO Lake Trout netting efforts have provided a crude measure of relative Walleye abundance. Walleye were collected at one sample site near the Pack River in a repeated spring net set between 2007 and 2010 (IDFG, unpublished data). Most Walleye caught at this site were mature adults. However, in 2010, juvenile production was first document by the capture of multiple younger age classes in the POR (Maiolie et al. 2011). POR samples suggested Walleye abundance was likely expanding in both abundance and distribution. However the available information did not provide a basin wide status of Walleye. In 2011, a comprehensive fall Walleye index survey was completed to better describe the current condition of the population.

Continued monitoring of Walleye abundance and distribution in LPO and the POR is essential for fisheries managers to understand how this new introduced piscivorous species may impact the existing fish community of the Pend Oreille system. Our objective was to continue a Walleye monitoring program that provided an understanding of current abundance and distribution of Walleye in LPO and the POR.

Yellow Perch are also an important component of the Pend Oreille basin fishery. Anglers typically target Yellow Perch during the winter months as an ice fishery or less commonly during spring and early summer months in open water. In recent years, Yellow Perch anglers have commented that fish size and abundance has declined. Anglers have speculated that the abundance of Yellow Perch is linked to increasing Walleye abundance and/or small size fish may reflect a stunted growth pattern. Yellow Perch are common bycatch associated with fall gill net surveys. As such, we included a more specific evaluation of Yellow Perch growth and recruitment in association with our 2014 survey efforts to help inform fisheries managers and the angling public.

METHODS

We completed a survey of Walleye abundance and distribution in LPO and the POR following standardized Fall Walleye Index Netting (FWIN) protocols described in the FWIN Manual of Instructions (Morgan 2002). Sample locations were randomly selected, but were focused primarily within the northern portion of LPO (Clark Fork River delta to POR mouth) and the POR (Figure 54). These areas contained water depths consistent with FWIN protocol. Much of LPO was not compatible with the selected sampling protocol due to existing bathymetry. In addition to survey effort in the northern portion of the basin, we sampled a limited portion of the southernmost tip of LPO (Idelwild and Scenic Bays) to assist in describing distribution on a larger scale. Bathymetry also limited available sample locations in this zone. Selected sample zones were defined within the 25 m depth contour. We also excluded two areas from sampling due to concerns with overlapping Bull Trout *Salvelinus confluentus* distribution and associated potential bycatch. Excluded areas included the Pack River mouth and the lower most portion of the Pend Oreille River in Idaho downstream from the historic community of Thema. The total area included in the survey was approximately 10,000 Ha. We set a total of 48 nets based on sample size recommendations described in FWIN protocol and prior knowledge of catch rate variability described in our 2011 FWIN survey of LPO.

We used monofilament experimental gill nets described in the FWIN protocol to sample fish. Nets were eight panel monofilament 1.8-m deep, 61.0-m long, with 7.6-m panels measuring 25-, 38-, 51-, 64-, 76-, 102-, 127-, and 152-mm stretched mesh. Net sets were equally divided between two depth strata including 2–5 m and 5–15 m depths. All nets were placed perpendicular to the shoreline. Netting was conducted at water temperatures between 10 and 15 °C. Net sets were approximately 24 hours in length. Catch per unit effort (CPUE), calculated as catch per net, was used to describe relative abundance of Walleye. The arithmetic mean of CPUE was used to describe average relative abundance among all samples.

Upon removal from gill nets all Walleye were measured (TL; mm) and weighed (g). All non-target species were measured and a sub-sample weighed. We collected otoliths from all Walleye and from a subsample of Yellow Perch from three sample locations on the POR for estimation of age.

We estimated age by examining otoliths under a dissecting microscope in whole view or by breaking centrally, browning, sanding, and viewing the cross section. Walleye growth patterns were evaluated using estimated fish ages to determine mean length at age at time of capture by sex. Growth patterns of Yellow Perch were also evaluated, but only by length at age at time of capture. We used growth of Yellow Perch to describe the potential of stunting in the population. Yellow Perch ages from subsampled fish were applied to the remaining sample by proportion using an age-length key. Catch at age was reported as a descriptor of annual recruitment and mortality in both species.

We used indices of condition to describe the general health of the Walleye population. Specifically, we estimated a visceral fat index (VFI) and a gonadal somatic index (GSI) from sampled fish. Indices were estimated as the ratio of visceral fat weight (VFI) and gonad weight (GSI) to body weight and described as a percentage. Visceral fat indices describe Walleye condition and are positively correlated to age at maturity (Henderson and Morgan 2002).

We estimated rates of sexual maturity in captured Walleye by examining all Walleye and ranking each individual as mature or immature (Duffy et al. 2000). Maturation rates are inversely related to growth rate and may reflect shifting population dynamics (Gangl and Pereira 2003, Schneider et al. 2007). We determined total length and age at 50% maturity using logistic regression (Quinn and Deriso 1999). We also calculated a female diversity index value based on the Shannon diversity index to describe the diversity of the age structure of mature females (Gangl and Pereira 2003). The female diversity index has been shown to be sensitive to changes in population structure (Gangl and Pereira 2003).

RESULTS

FWIN sampling was conducted between October 1 and October 9, 2014. We completed 48 net nights among all sampled areas. A total of 105 Walleye were collected comprising 4.0% of the total catch. Walleye CPUE ranged from 0 to 10 Walleye per net. Walleye were captured at 33 of 48 sample sites. Relative abundance measured as arithmetic mean CPUE for Walleye of all age classes was 2.2 fish/net (± 0.50, 80% CI). Although we did not capture Walleye in every net, we did capture Walleye in representative samples throughout LPO and the POR (Figure 54). Walleye catch was distributed across areas where netting occurred. As an example, 34% of Walleye captured were caught in the POR representing 31% of the nets set in the survey.

We collected 22 other species in the bycatch associated with Walleye netting which included: Black Bullhead *Ictalurus melas* (0.3%), Black Crappie *Pomoxis nigromaculatus* (1.3%), Bluegill *Lepomis macrochirus* (>0.1%), Brown Bullhead *Ameiurus nebulosus* (1.1%), Brown Trout *Salmo trutta* (0.5%), Bull Trout (0.1%), Kokanee (0.5%), Largemouth Bass *Micropterus salmoides* (0.2%), Longnose Sucker *Catostomus catostomus* (1.1%), Largescale Sucker *Catostomus macrocheilus* (2.4%), Lake Whitefish *Coregonus clupeaformis* (17.8%), Mountain Whitefish *Prosopium williamsoni* (0.6%), Northern Pike *Esox lucius* (0.3%), Northern Pikeminnow *Ptychocheilus oregonensis* (9.6%), Peamouth *Mylocheilus caurinus* (15.5%), Pumpkinseed *Lepomis gibbosus* (1.4%), Rainbow Trout *Oncorhynchus mykiss* (0.2%), Smallmouth Bass *Micropterus dolomieui* (5.3%), Tench *Tinca tinca* (4.4%), Westslope Cutthroat Trout *Oncorhynchus lewisi* (0.4%), Westslope Cutthroat x Rainbow Trout Hybrids (> 0.1%), and Yellow Perch *Perca flavescens* (32.9 %) (Table 20). Mean length and weight of collected species is presented in Table 20.

Total length of sampled Walleye ranged from 137 to 805 mm (Figure 55). PSD of the sampled population was 54.8 (45.2–64.4, 95% CI). Walleye of stock size (at least 249 mm) and greater made up 99% of the sampled population. Forty two percent of the sampled Walleye were of preferred length (at least 509 mm) or greater (Figure 55).

Walleye collected in sampling efforts had a mean GSI value of 1.6 and 1.9 (± 0.3; 80% CI) for males and females, respectively. Mean visceral fat indices were 3.1 and 4.8 (± 0.5; 80% CI) for male and female Walleye, respectively.

Eight age classes were present in the samples representing fish of age classes zero, one, two, three, four, five, seven, and eleven (Figure 56). The majority of Walleye sampled were assigned to either the two or five year age classes. Age classes zero, seven, and eleven were represented by only one or two fish among all net samples.

Growth rates of sampled Walleye varied by sex. Female growth described by length at age was greater than comparable male growth when viewed across all age classes, with separation between sexes increasing with age (Figure 57). Mean length for age-2 fish at capture did not yet demonstrate strong divergence with mean lengths of 358 and 359 mm for males and females, respectively.

Female (56%) Walleye were more dominant in our catch than males (43%; Figure 58). Fifty-one percent of both male and female Walleye were mature. Length at 50% maturity for female Walleye was estimated at 505 mm. Length at 50% maturity for male Walleye was estimated at 375 mm. Thirty-six percent of age-2 male Walleye were mature. Although we estimated maturation rates, it is likely our estimates were impacted by sample size and limited representation of several age classes. Eighty-three percent of the mature female Walleye observed in our sample were assigned to one year class (age-5). Female diversity was low indexed at 0.27.

Yellow Perch in the Pend Oreille basin demonstrated good growth. Subsampled fish reached 200 mm in approximately 3 years (Figure 59). Six age classes were present in our sample. However, recruitment appeared sporadic with age one Yellow Perch making up 87% of all age classes present in our sample (Figure 60).

DISCUSSION

Catch rates observed in our survey of Walleye in the Pend Oreille basin (CPUE, 2.2 ± 0.5) suggest abundance has increased since our last survey (CPUE, 1.4 ± 0.7; Fredericks et al. 2013). However, overlapping confidence bounds limit the significance of the observed increases. Observed recruitment in each year since 2011 indicates that the population is growing with successful recruitment. Only sporadic year classes were present in the 2011 survey. Although Walleye abundance appears to be increasing, catch rates continue to represent a low-density population. In comparison, average CPUE from FWIN surveys in southern Idaho reservoirs with established populations were considerably higher than the Pend Oreille basin ranging from 19 to 34 Walleye per net (Ryan et al. 2009, IDFG unpublished data). A similar scale of catch rates was identified in Washington state Walleye populations using the FWIN survey protocol with a mean catch rate reported from across multiple waters of 19 Walleye per net (WDFW 2005).

FWIN catch rates are a reflection of abundance in suitable Walleye habitat, which represents a relatively small portion of the Pend Oreille basin. In our survey, we sampled water depths up to 15 m consistent with FWIN protocol and within depths reasonably fished with the gear used in the survey (Morgan 2002). As such our survey did not cover the main LPO basin, much of which is deep water (> 100 m) with steep near-shore bathymetry. Although Walleye are known to occupy at least portions of the near-shore habitat in the main lake basin, we suspect much of the basin is not occupied or has lower densities of Walleye. Had we surveyed that portion of the system, our reported average CPUE would have likely been lower.

Our observation of multiple year classes provides evidence of increasing recruitment potential in the Walleye population. In 2011, we expected a two year old year class would largely be mature within the following two years, resulting in a significant increase in spawning potential. Consistent recruitment evidenced by the presence of Walleye in year classes zero through five in 2014 confirmed a threshold of production has been crossed. Despite this shift in production, the availability of mature female Walleye remains low. A female diversity index value closer to one would represent a fully functioning population (Gangl and Pereira 2003). As a generation of Pend Oreille Walleye is established, it is likely recruitment potential will continue to increase. Although year classes are consistent, year-class strength appeared inconsistent. Inconsistent Walleye recruitment has been linked to multiple factors including adult Walleye abundance, spring water temperature, and abundance of other prey and predator fish species (Hansen et al. 1998).

Pend Oreille basin Walleye continued to demonstrate rapid growth and above average condition. Visceral fat indices of male and female Walleye represented healthy robust individuals with values ranging from 3.5 to 4.8. Values changed little from those reported in 2011 (3.5 to 4.5). In comparison, visceral fat indices from southern Idaho waters have been reported to range from 1.3 to 3.8 for male and female Walleye (Ryan et al. 2009). These measures of physical condition suggested an abundance of forage. Reported bycatch reflected similar relative abundance of non-target species in 2011. Dominant species in the catch in 2011 and 2014 included Yellow Perch, Northern Pikeminnow, Peamouth, and Lake Whitefish.

Walleye populations may exhibit density-dependent growth (Muth and Wolfert 1986, Sass et al.2004). Although, regional patterns of density-dependent growth may be difficult to detect due other influential factors such as water temperature and productivity, shifts within waters may be evident especially within dramatic shifts in abundance. Pend Oreille Basin Walleye growth, comparatively evaluated as length at age-2, demonstrated rapid initial growth beyond that experienced in other regional waters of similar latitude. Fredericks et al. (2011) reported estimates of mean length at age-2 in this system at lengths greater than 400 mm for male and female Walleye. Comparatively, length at age-2 for other area waters have been observed to range from 276–350 mm (Ryan et al. 2009, Horn et al. 2009). However, estimates of mean length at age-2 for Pend Oreille Basin Walleye declined by approximately 50 mm in our 2014 survey. Our observations combined with increased relative abundance suggest density-dependent limitation in growth may be occurring as this newly established population expands. It seems unlikely that accelerated growth, as observed in 2011, would continue given the relatively low productivity habitat provided within the Pend Oreille system.

Maturation of male Walleye has been generally described as initiating at a range of 2 to 9 years of age or beyond a threshold of 34 cm (Kerr et al. 2004). Walleye in our survey conformed to this generalization. Maturation rates observed in 2014 represented increases in length and age at 50% maturity from 2011. Observed shifts in maturation rates were anticipated as a result of increased Walleye density and were consistent with our observations of increasing relative abundance and decreasing growth rate.

Our 2014 FWIN survey will provide a means of monitoring long term trends in Walleye abundance and distribution in the Pend Oreille basin. Although it is unclear to what extent Walleye will expand within the system, it is important to recognize the presence of Walleye and the potential impact they may have on other fish species. Management of other fishes such as kokanee, Rainbow Trout, and Bull Trout all have potential to be impacted by the presence of a new predatory fish in the community.

Pend Oreille basin Yellow Perch demonstrated reasonable growth and did not show evidence of stunting. The definition of stunted growth is subjective, but comparing growth rates to those from other waters provides some reference to the condition of our population. Gabelhouse (1984) defined quality length in Yellow Perch as fish between 200 and 250 mm in length. Diana and Salz (1990) suggested Lake Huron Yellow Perch in Saginaw Bay were stunted, taking five plus years to reach 200 mm. Comparatively, Pend Oreille basin Yellow Perch grew rapidly into a 200 mm size range in three years, suggesting fish were not stunted. Although our data provided an estimation of length at age, our sample sizes of estimated ages for older age classes were small. We recommend future efforts prioritize age sample collections throughout the surveyed areas that ensure adequate sample sizes for all sizes encountered.

While Yellow Perch growth rates appear to be good, sporadic year class strength suggested recruitment is highly variable and is likely the cause of reduced angling opportunity in some years. Cyclic dynamics, where individual age classes dominate a Yellow Perch population for multiple years, have been observed in other fish communities (Sanderson et al. 1999). In this example, abundance of juvenile and mature adult Yellow Perch was most influential in the success of recruitment. Although our observed age distribution is consistent with a cyclic recruitment scenario, it does not conclusively remove the potential interaction of predatory fish or other habitat conditions on abundance. If sporadic recruitment were occurring due to cyclic dynamics related to the abundance of present year classes or other factors, we would expect periodic recruitment pulses to carry through from year to year with additional pulses occurring in out years. We recommend continued monitoring of Yellow Perch in association with future FWIN surveys to help confirm the mechanisms at work.

MANAGEMENT RECOMMENDATIONS

1. Continue FWIN surveys on a three-year rotation to evaluate changes in relative abundance and distribution as well as corresponding shifts in non-target species.

2. Monitor Yellow Perch in association with FWIN surveys to assess the influence of mortality on developing strong and weak year classes and the presence of quality size fish in the population.

Table 20. Catch summary of fish collected in 2014 FWIN survey of Lake Pend Oreille and the Pend Oreille River, Idaho. Summary statistics included catch (*n*) and percent catch by species, average total length (Avg TL), standard deviation of measured total lengths (SD TL), average weight (Avg Wt), and standard deviation of measured fish weights (SD Wt).

Species	*n*	% Catch	Avg TL	SD TL	Avg Wt	SD Wt
Black Crappie	33	1.3%	162	61	105	225
Bluegill	1	0.0%	110	--	26	--
Black Bullhead	7	0.3%	248	35	211	79
Bull Trout	2	0.1%	489	30	1002	214
Brown Bullhead	28	1.1%	239	54	201	113
Brown Trout	14	0.5%	465	69	1068	507
Kokanee	13	0.5%	278	14	192	33
Largemouth Bass	6	0.2%	338	111	827	821
Longnose Sucker	28	1.1%	342	86	468	253
Largescale Sucker	61	2.4%	422	124	1011	682
Lake Whitefish	463	17.8%	330	63	304	175
Mountain Whitefish	15	0.6%	293	52	234	94
Northern Pike	7	0.3%	719	235	2268	1447
Northern Pikeminnow	250	9.6%	340	86	427	348
Peamouth	401	15.5%	259	66	126	104
Pumpkinseed	36	1.4%	109	25	32	22
Rainbow Trout	5	0.2%	360	54	424	137
Cutthroat x Rainbow Hybrid	1	0.0%	450	--	690	--
Smallmouth Bass	138	5.3%	330	94	680	557
Tench	115	4.4%	431	72	1174	378
Westslope Cutthroat Trout	11	0.4%	373	31	443	92
Walleye	105	4.0%	465	142	1462	1309
Yellow Perch	854	32.9%	152	31	38	38

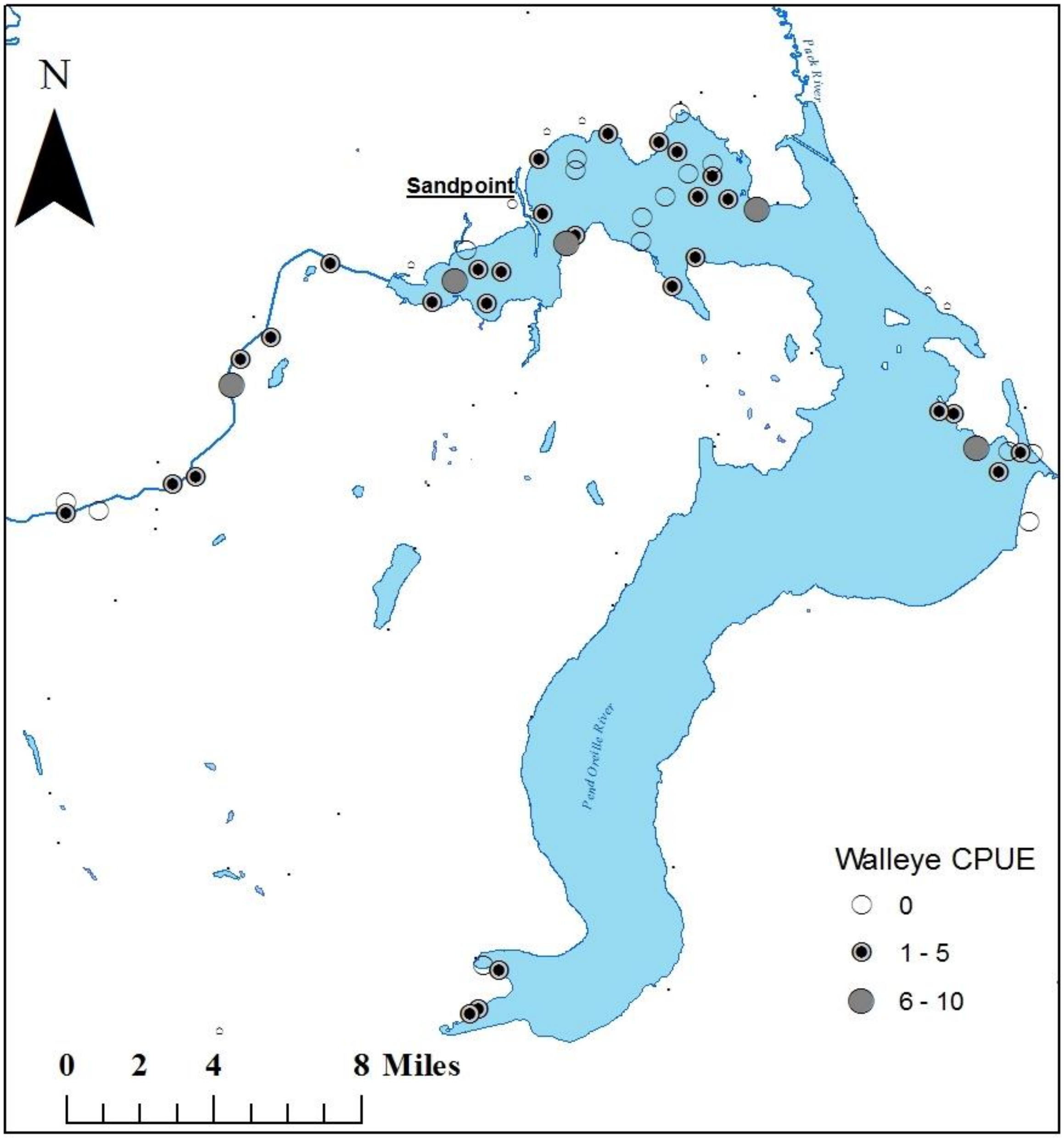

Figure 54. Fall Walleye index netting sample locations in the Pend Oreille Basin, Idaho 2014. Sample sites displayed by catch per unit effort (fish/net night).

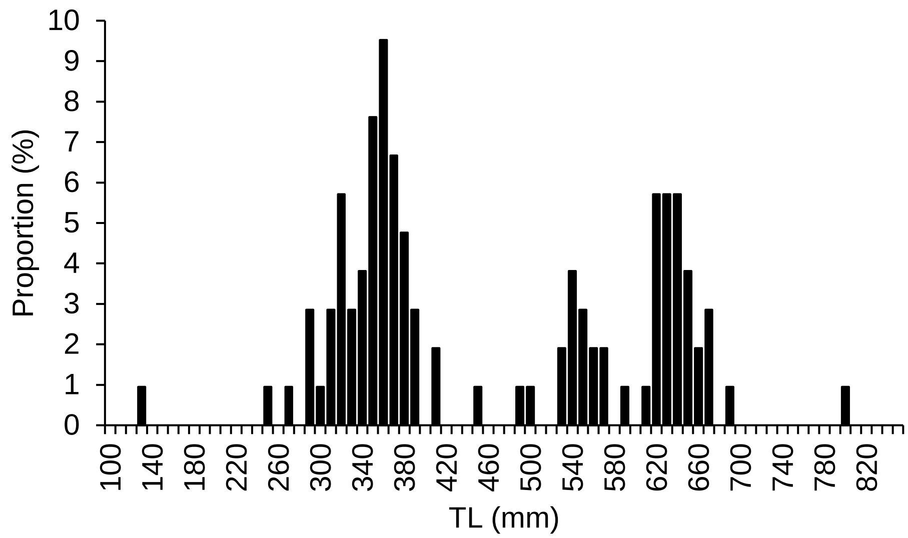

Figure 55. Proportion of sampled Walleye by total length collected in 2014 FWIN sampling of Lake Pend Oreille and the Pend Oreille River, Idaho.

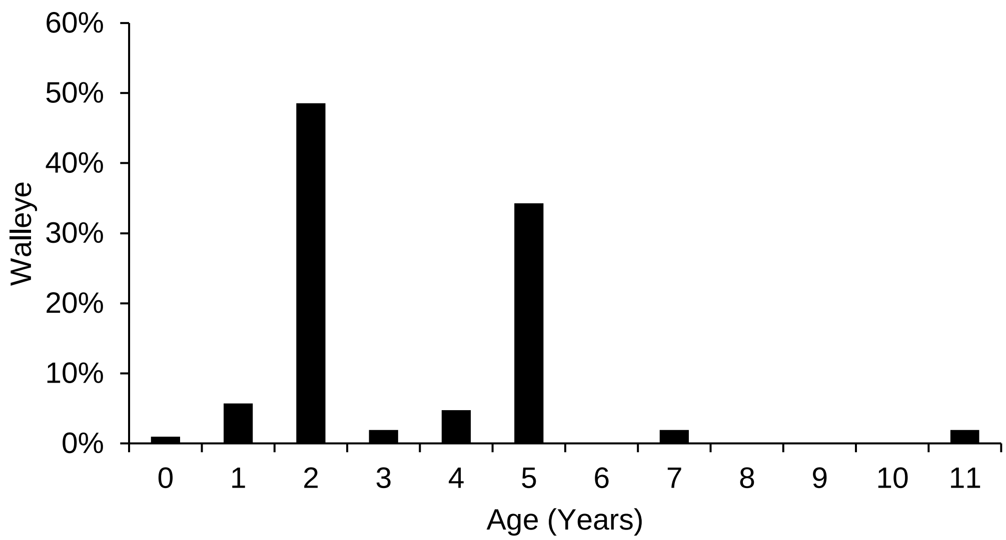

Figure 56. Proportion of sampled Walleye by age collected in 2014 FWIN sampling of Lake Pend Oreille and the Pend Oreille River, Idaho.

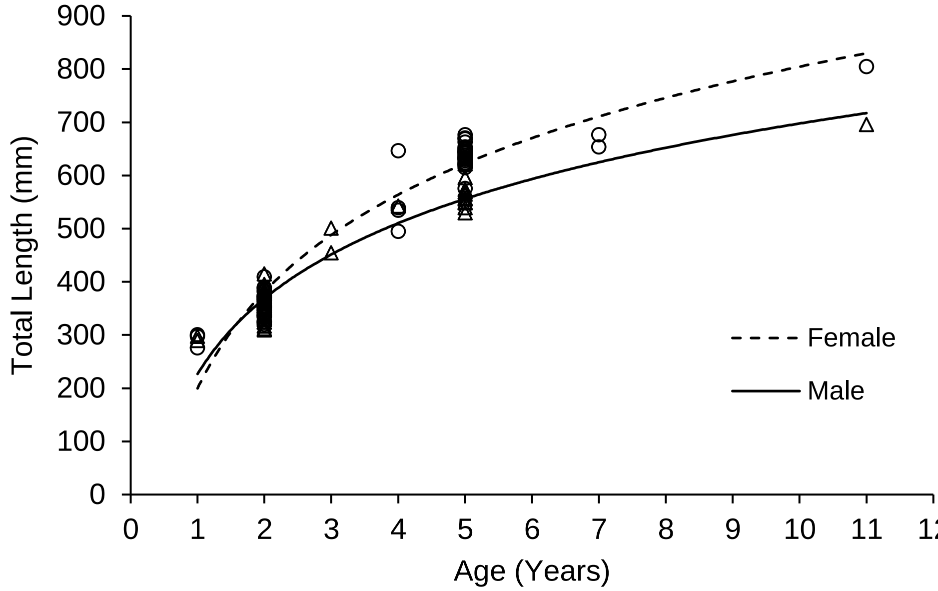

Figure 57. Mean total length at age of male and female Walleye collected in 2014 FWIN sampling of Lake Pend Oreille and the Pend Oreille River, Idaho.

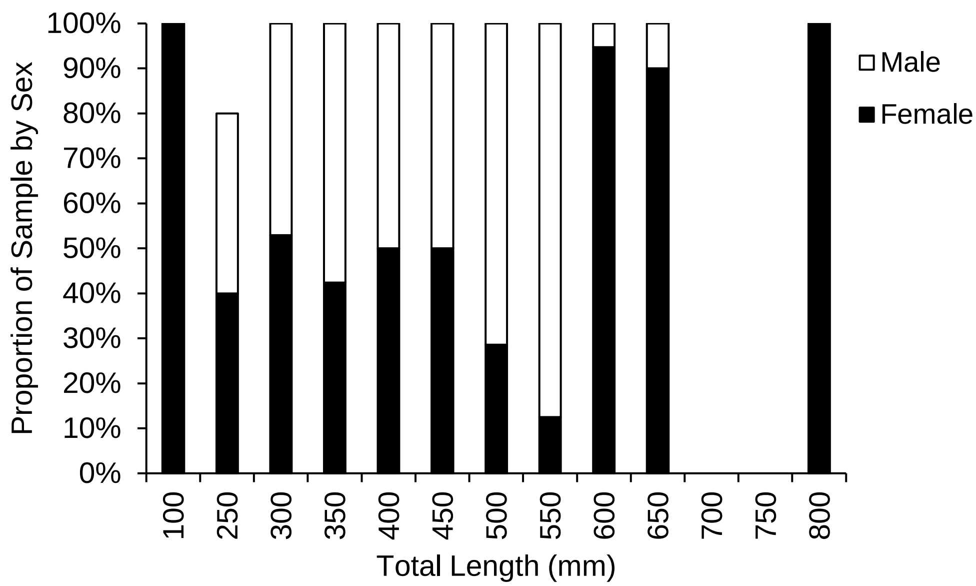

Figure 58. Proportions of male and female Walleye collected in 2014 FWIN sampling of Lake Pend Oreille and the Pend Oreille River, Idaho.

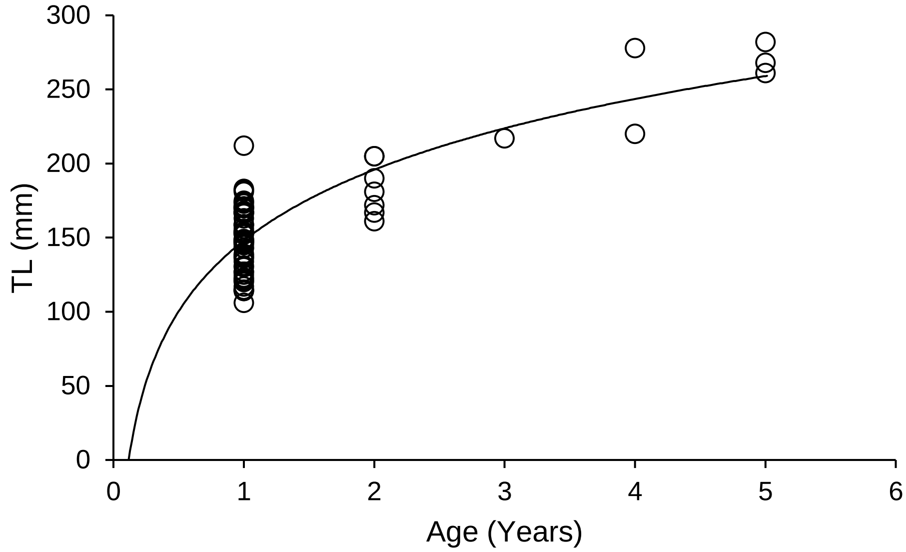

Figure 59. Mean total length (mm) at age of Yellow Perch collected in 2014 FWIN sampling of Lake Pend Oreille and the Pend Oreille River, Idaho.

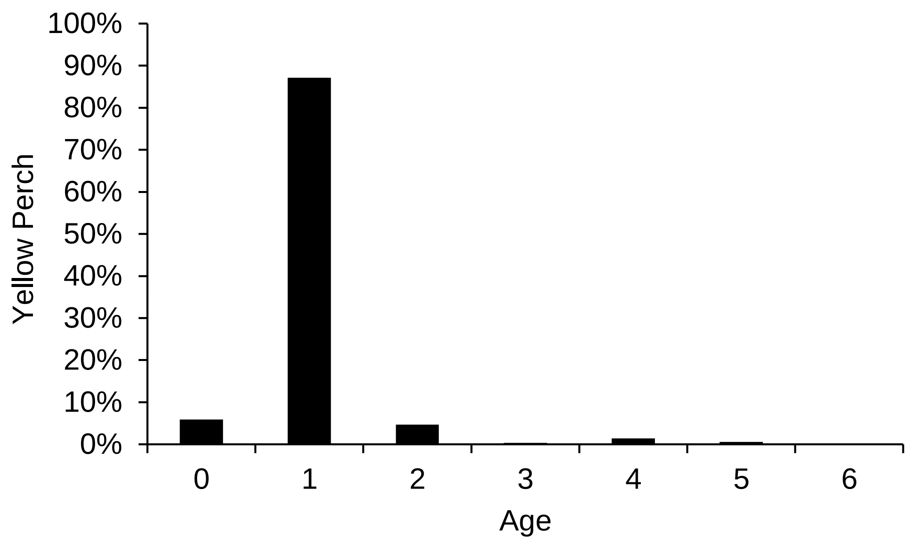

Figure 60. Proportion of sampled Yellow Perch by age (years) collected in 2014 FWIN sampling of Lake Pend Oreille and the Pend Oreille River, Idaho.

ALPINE LAKE FISHERY EVALUATIONS

ABSTRACT

Wild populations of Brook Trout are common in alpine lakes throughout western North America, including Idaho. Brook Trout tend to be highly prolific and are successful at establishing self-sustaining populations in alpine lakes because they are early maturing, have few predators, and are able to spawn with limited habitat. Brook Trout have the potential to reach very high abundances in alpine lakes, whereby growth rates can be substantially reduced from intraspecific competition. Oftentimes, this will result in “stunted” populations with poor size structure and few individuals that are desirable to anglers. To evaluate the occurrence of this phenomenon in Panhandle Region alpine lakes, we estimated characteristics of known Brook Trout populations in the Spokane and Kootenai river drainages. Specifically, we estimated catch rates, size structure, body condition, and habitat characteristics to identify alpine lakes that may benefit from treatments aimed at reducing Brook Trout abundance. Catch rates were highly variable among lakes (4.8–70 fish/net night), but only slightly variable within lakes (mean SD = 3.9 fish/net night).The majority of alpine lakes in this study were composed of Brook Trout ≥ 200 mm in total length; however, Upper Glidden Lake, Roman Nose Lake 2, and Lower Stevens Lake had slightly better size structure. This pattern is likely related to previous efforts to improve Brook Trout size structure through predator introductions. Future work should focus on evaluating the remaining alpine lakes in the Panhandle Region with known Brook Trout populations so that managers have a complete understanding of how population characteristics vary. In addition, future work should identify alpine lakes that may benefit from population renovation (i.e., abundance reduction) or eradication.

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INTRODUCTION

High alpine lakes are among the most unique and ecologically-intact lentic systems worldwide. Alpine lakes are also an important resource that attract recreationists for both consumptive (e.g., angling) and non-consumptive (e.g., wildlife viewing, hiking) uses. Mountainous regions throughout the world contain alpine lakes that were formed from the recession of glacial ice during the late Pleistocene Epoch (Knapp et al. 2001b). The glacier-carved landscape left steep topography where alpine lakes have formed, precluding the colonization of fish into high elevation tributaries and lake outlets. In western North America, nearly all (~ 95%) of alpine lakes were historically fishless; however, many lakes have been stocked over the course of the past century with nonnative fishes (mostly salmonids) to create recreational fisheries (Bahls 1992; Matthews and Knapp 1999; Pister 2001). Overall, around 60% (SD = 12%) of alpine lakes throughout the western United States have been stocked with sport fish species to provide recreational angling opportunities (Bahls 1992).

The first documented stockings of alpine lakes are thought to have occurred during the latter part of the 19th century and were initiated by the Sierra Club. Various salmonid species were loaded into milk cans, packed to stock animals, and released into alpine lakes throughout the Sierra Nevada Mountains (Matthews and Knapp 1998). Following these efforts, state and federal management agencies, along with private citizens, have stocked alpine lakes across the western United States in an effort to establish recreational fisheries (Landres and Matthews 2001). More recently, improvements in technology (i.e., fixed- and rotary-wing aircraft) have allowed management agencies to stock fish into more lakes, thereby expanding the distribution of fish in alpine lakes and increasing stocking frequency. While the increase in alpine lake stocking has provided recreational anglers with more consistent opportunities, it has been shown that faunal communities can be adversely influenced by introduced fishes (Parker et al. 2000). Predation by fishes has been implicated in the decline in abundance and diversity of zooplankton, macroinvertebrate (Knapp et al. 2001a; Parker et al. 2000), and amphibian (Pilliod and Peterson 2000) assemblages in alpine lakes because these species' metapopulations did not co-evolve in the presence of fish. Particular concern surrounding endemic amphibian species in alpine lakes has resulted in many state agencies implementing efforts to monitor and evaluate stocking (Knapp et al. 2001a; Pilliod and Peterson 2001).

Many of the naturalized fish populations in alpine lakes consist of Brook Trout *Salvelinus fontinalis*. Brook Trout have been extensively stocked into alpine lakes throughout western North America (Hall 1991), including Idaho. Brook Trout stocking mainly took place during the early 20th century, but efforts ceased around the mid-1950s when other species (e.g., Westslope Cutthroat Trout *Oncorhynchus clarki lewisi*, Golden Trout *O. aguabonita*) could be successfully cultured and stocked into alpine lakes. Brook Trout have been particularly successful at establishing naturalized, self-sustaining populations in alpine lake ecosystems (Hall 1991; Parker et al. 2000; Koenig 2012). Brook Trout are capable of spawning in lake inlets, outlets, and margins even when little habitat is available (Fraser 1980), thus contributing to their continued persistence in alpine lakes. Brook Trout have few predators in high elevation environments, and this, coupled with their early age at maturity, has allowed many populations to reach very high abundances (Donald and Alger 1989). Alpine lakes are often highly unproductive (Parker et al. 2000) and unable to support high densities of fish. Due to the lack of limited primary production in alpine lakes, Brook Trout are prone to stunting once densities reach critical thresholds, thus resulting in poor size structure and limited interest from anglers. Additionally, alpine lakes may act as source populations for downstream colonization of Brook Trout which may pose threats to native fish assemblages in downstream habitats. Brook Trout are known to compete with Cutthroat Trout spp. (Marnell 1988) and hybridize with native Bull Trout *S. confluentus*. Dispersal of Brook Trout from overcrowding and intraspecific competition in source environments may lead to the invasion of stronghold habitats, and subsequent displacement or competition with native fishes (Shepard et al. 2005).

Given the threat to native faunal assemblages and lack of quality fishing opportunity provided by Brook Trout, some agencies have initiated efforts to eradicate Brook Trout from alpine lakes or reduce densities through various biological (e.g., introduction of predators), mechanical (e.g., gill netting), and chemical (e.g., rotenone) techniques. Complete removal of Brook Trout in many alpine lakes is highly unlikely due to logistical and financial restraints. Therefore, management is often focused on practical means of reducing Brook Trout densities and improving size structure in hopes of providing a quality fishery for anglers and reducing threats to downstream fish assemblages.

There are approximately 140 alpine lakes (defined as lentic system ≥ 1,000 m elevation) within the Panhandle Region that have been previously identified and characterized by Hardy et al. (2009). Fifty-one are managed as put-grow-and-take fisheries and stocked with Westslope Cutthroat Trout, Rainbow Trout *O. mykiss*, Golden Trout *O. aguabonita*, or Arctic Grayling *Thymallus arcticus*. These 51 alpine lakes are stocked on a two-year schedule at densities of ~750 fry/ha based on elevation (Fredericks et al. 2002). Of the remaining 89 alpine lakes that are not stocked, around 15–20 have known populations of wild Brook Trout (Hardy et al. 2009).

Brook Trout are fairly common in alpine lakes throughout much of Idaho, and they often exhibit strong density-dependent growth. For example, Brimmer et al. (2002) reported drastic declines in size structure of a former trophy Brook Trout fishery in Carlson Lake in the Salmon Region following an increase in abundance. Similarly, Schriever and Murphy (2010) reported that Brook Trout size structure increased after a large-scale removal in Ice and Rainbow lakes in the Clearwater Region. Previous investigations of Brook Trout in alpine lakes around Idaho have shown a similar relationship between density and growth (Koenig 2012), and various methods have been used to eradicate Brook Trout and experimentally reduce densities. Depending on the management objective and practicality, it may be advantageous to completely remove Brook Trout and stock a species that is unlikely to successfully reproduce or is less prone to stunting. Alternatively, the objective may be to manage for a quality Brook Trout fishery and encourage harvest-oriented angling. For instance, the Idaho Department of Fish and Game used rotenone treatment to eradicate Brook Trout from Porcupine Lake and the system was restocked with Westslope Cutthroat Trout (unpublished data). Idaho Department of Fish and Game has also introduced predators (i.e., Bull Trout and Brown Trout *Salmo Trutta*) to improve size structure of Brook Trout in alpine lakes which are managed as Brook Trout fisheries (Hardy 2009).

OBJECTIVES

1. Estimate and compare population characteristics of Brook Trout populations among alpine lakes.
2. Identify management treatments that may be used to improve angling quality in alpine lakes with overabundant Brook Trout populations.

STUDY AREA

The study area consisted of alpine lakes in the headwaters of the Spokane and Kootenai river basins in northern Idaho. All of the alpine lakes in the study area share characteristics in common with typical high alpine lakes throughout western North America. This includes high elevations (≥ 2,000 m), small size (< 30 ha) short growing seasons (3–5 months ice-free), cold water temperatures, low productivity, and relatively simple fish assemblages. All of the surveyed alpine lakes (complete list in Table 21) have known Brook Trout populations and are located in IDFG's Panhandle Region. Historically, dominant, land-use activities in this region have included logging, mining, and livestock grazing (DEQ 2001).More recently, declines in timber harvest and mining activity have positively influenced water quality and fish habitat throughout the watersheds included in this study. Despite extensive land use, however, aquatic habitat in alpine lakes within the study area has remained relatively unaltered due to difficult access and remoteness.

Alpine lakes are commonly characterized by having limited access, low angler densities, and high catch rates making them appealing to anglers seeking a remote angling experience. Elsie Lake and Lower Glidden Lake have direct road access, and as such, are popular spots for local recreationists. Given the high angler use and poor size structure of wild Brook Trout in Elsie and Lower Glidden lakes, the IDFG stocks catchable Rainbow Trout to improve angling opportunity. With the exception of Elsie and Lower Glidden lakes, the remaining alpine lakes in this study have fish assemblages composed only of wild Brook Trout.

METHODS

Brook Trout were sampled from 8 alpine lakes in northern Idaho during July–September 2014. The alpine lakes had different characteristics varying in elevation from 1,548.4–1,813.9 m, in surface area from 3.5–11.2 ha, and in maximum depth from 4.5–28.9 m (Table 21).We sampled fishes using floating experimental-mesh gill nets (36.0 m × 1.8 m with panels of 12.70, 19.05, and 25.40-mm stretch-measure mesh). Initially, we made attempts to pair sinking monofilament gill nets with floating gill nets; however, sinking gill nets continually snagged on benthic structure making net retrieval difficult and dangerous. Two gill nets were set in lakes less than 5 ha in surface area and three nets were set in lakes greater than 5 ha in surface area to adequately characterize the population in each lake. Gill nets were deployed approximately one hour before dusk and retrieved shortly after dawn the following day. Upon retrieval, we enumerated the total catch for each net and recorded the mesh size corresponding to each captured fish. We recorded total length (TL; mm) and weight (g) from all sampled fishes. Secchi depth, maximum lake depth, conductivity, the number of campfire rings, and the number of camp sites were recorded during each sampling event. In addition, we also used a categorical score (Low–High) to indicate the level of human use at each lake (Knight 2009).

Catch-per-unit-effort (CPUE) was estimated as the number of fish sampled per gill net per night. Length frequency distributions were used to describe and compare size structure among populations. Body condition of Brook Trout was evaluated using relative weight (W_r; Neumann et al. 2012).Relative weight values were calculated as

$$W_r = (W / W_s) \times 100,$$

where W is the weight of an individual and W_s is the standard weight predicted by a species-specific length-weight regression (Neumann et al. 2012). A W_r value of 100 indicates average body condition, W_r values below 100 indicate poor body condition, and W_r values above 100 indicate good body condition.

RESULTS

A total of 924 Brook Trout was sampled from the eight lakes. Catch rates were highly variable among lakes, but only slightly variable within lakes (Table 22). Mean total length of Brook Trout was relatively consistent (141–191 mm) among lakes with the exception of Brook Trout in Roman Nose Lake 2 which had a mean total length of 412.1 mm (Table 22). We did not sample any stock length individuals in any lakes, except Roman Nose 1 and Roman Nose 2 lakes which had 1 and 3 stock-length Brook Trout, respectively (Figure 61). The majority of each population was composed of Brook Trout that were less than 200 mm TL. Mean weight of Brook Trout varied from 34.9–67.5 g and body condition was slightly below average for most populations (Table 22; Figure 63).

DISCUSSION

Size structure among the Brook Trout populations in our study sites was relatively poor with the majority of individuals being ≤ 200 mm (Figure 62; Figure 63).The vast majority of Brook Trout were small and likely undesirable to most anglers. We did not sample any stock-length or larger Brook Trout in the majority of our study sites, and in those were we did, sample sizes were not sufficient for calculating size structure metrics. Lower Stevens Lake, Roman Nose Lake 2, and Upper Glidden Lake had more Brook Trout ≥ 230 mm TL than the other study lakes. This is not surprising that Upper Glidden Lake and Roman Nose Lake 2 displayed better size structure because these lakes have been previously stocked with Bull Trout. These introductions were part of a larger project that occurred in 1993 investigating the use of Bull Trout and Brown Trout in high lakes to reduce Brook Trout Abundance. Both Upper Glidden Lake and Roman Nose Lake 1 showed significant (P < 0.05) increases in mean length-at-age of Brook Trout; however, Bull Trout persisted longer in these lakes than other lakes included in the study (i.e., Revett Lake, Roman Nose Lake 2). Upper Stevens Lake was used as a control as part of this study and no significant change in mean length-at-age of Brook Trout was detected over the 15-year course of the study (Hardy et al. 2008).

A considerable amount of research and management effort has focused on treatments that may be used to reduce Brook Trout abundances in both lentic and lotic systems. Due to the remoteness of many alpine lakes, biological treatments have been an effective and resourceful way to remove Brook Trout. Koenig (2012) built upon previous management-related work in Idaho by evaluating the use of tiger muskellunge *Esox masquinongy* × *E. Lucius* to eradicate Brook Trout. The authors reported that some post-treatment lakes showed substantial declines in CPUE and increases in mean length (4–133 mm) of Brook Trout, whereas nearby control lakes remained composed of slow growing Brook Trout. Our study sites that have not previously received treatments to reduce abundance would likely benefit from predator introductions or periodic mechanical remove (i.e., netting). Potential candidate lakes from this study include Revett Lake, Roman Nose Lake 1, and Upper Stevens Lake.

MANAGEMENT RECOMMENDATIONS

1. Sample remaining alpine lakes with known Brook Trout populations in 2015.

2. Consider the use of biological treatments (e.g., Tiger Muskellunge) to reduce Brook Trout abundance.

Table 21. Characteristics of alpine lakes sampled in the Panhandle Region, Idaho (2014). Alpine lakes are organized by parent drainage.

Lake	Year[a]	Elevation (m)	Surface area (ha)	Maximum depth (m)	Conductivity (µS/cm)	pH	Relative use[b]
		Spokane River Drainage					
Elsie	2014	1,548.4	6.2	14.6	34.8	8.7	High
Lower Glidden	2014	1,712.7	5.6	4.5	9.1	7.6	High
Lower Stevens	2014	1,692.3	11.2	28.7	52.3	8.0	Moderate
Revett	2014	1,730.4	8.2	12.2	6.0	7.7	Moderate
Upper Glidden	2014	1,800.5	7.6	28.9	7.8	7.3	Moderate
Upper Stevens	2014	1,752.9	4.9	26.0	45.7	8.09	Moderate
		Kootenai River Drainage					
Roman Nose 1	2014	1,800.5	6.8	18.2	9.7	7.7	High
Roman Nose 2	2014	1,813.9	3.5	7.0	7.5	7.7	High

[a]May be expressed as multiple years
[b]Subjective measure of human impact incorporating accessibility, number of campsites, and number of fire rings

Table 22. Sample size (*n*), mean catch-per-unit-effort (CPUE = fish/gill net night), total length (mm; Minimum–Maximum [Min–Max]) statistics, weight (g; Minimum–Maximum [Min–Max]) statistics, and relative weight (W_r) for Brook Trout populations sampled from alpine lakes in the Panhandle Region, Idaho (2014).Numbers in parentheses represent one standard error of the mean.

			Total length		Weight		
Lake	*n*	CPUE	Mean	Min–Max	Mean	Min–Max	W_r
Elsie	29	4.8 (1.6)	141.1 (7.9)	89–216	34.9 (5.9)	6–110	93.5 (2.9)
Lower Glidden	172	34.0 (7.5)	155.9 (2.4)	83–239	35.5 (1.6)	5–115	86.2 (0.9)
Lower Stevens	84	16.6 (4.3)	191.3 (4.2)	93–247	67.5 (3.7)	10–135	87.6 (1.4)
Revett	130	26.0 (2.5)	162.5 (3.3)	81–254	40.1 (2.2)	5–140	83.5 (1.2)
Roman Nose 1	140	70.0 (2.5)	158.2 (2.8)	77–334	45.3 (3.8)	5–533	97.3 (0.9)
Roman Nose 2	64	32.0 (6.5)	412.1 (7.8)	77–417	50.2 (14.1)	5–827	94.3 (1.6)
Upper Glidden	60	15.0 (2.4)	179.3 (5.9)	93–296	60.7 (5.1)	7–217	87.8 (1.6)
Upper Stevens	245	49.0 (3.9)	183.4 (0.9)	111–230	54.1 (0.9)	12–93	84.8 (1.1)

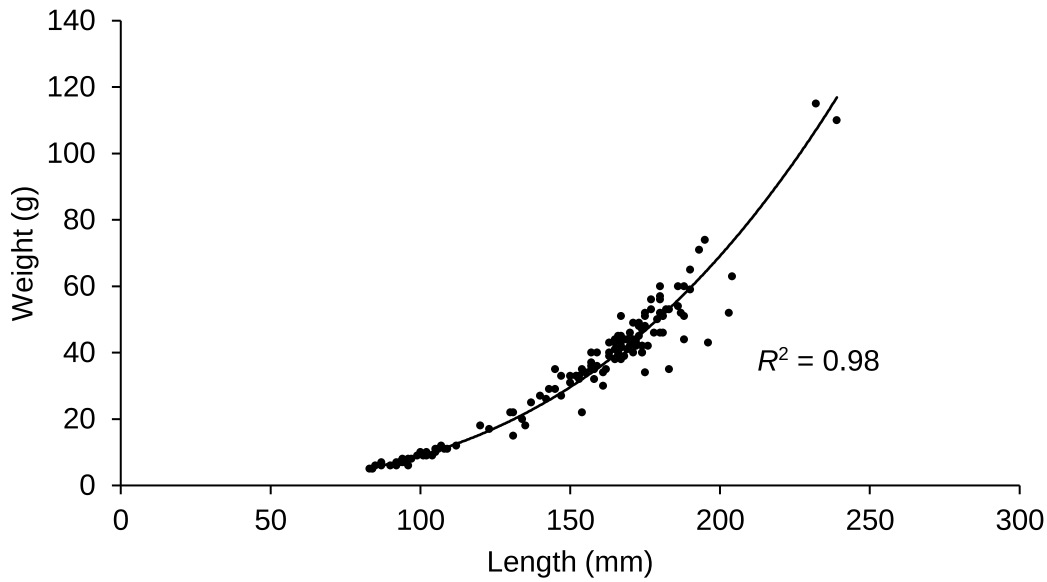

Figure 61. Length-weight relationship for Brook Trout sampled from alpine lakes in the Panhandle Region (2014).

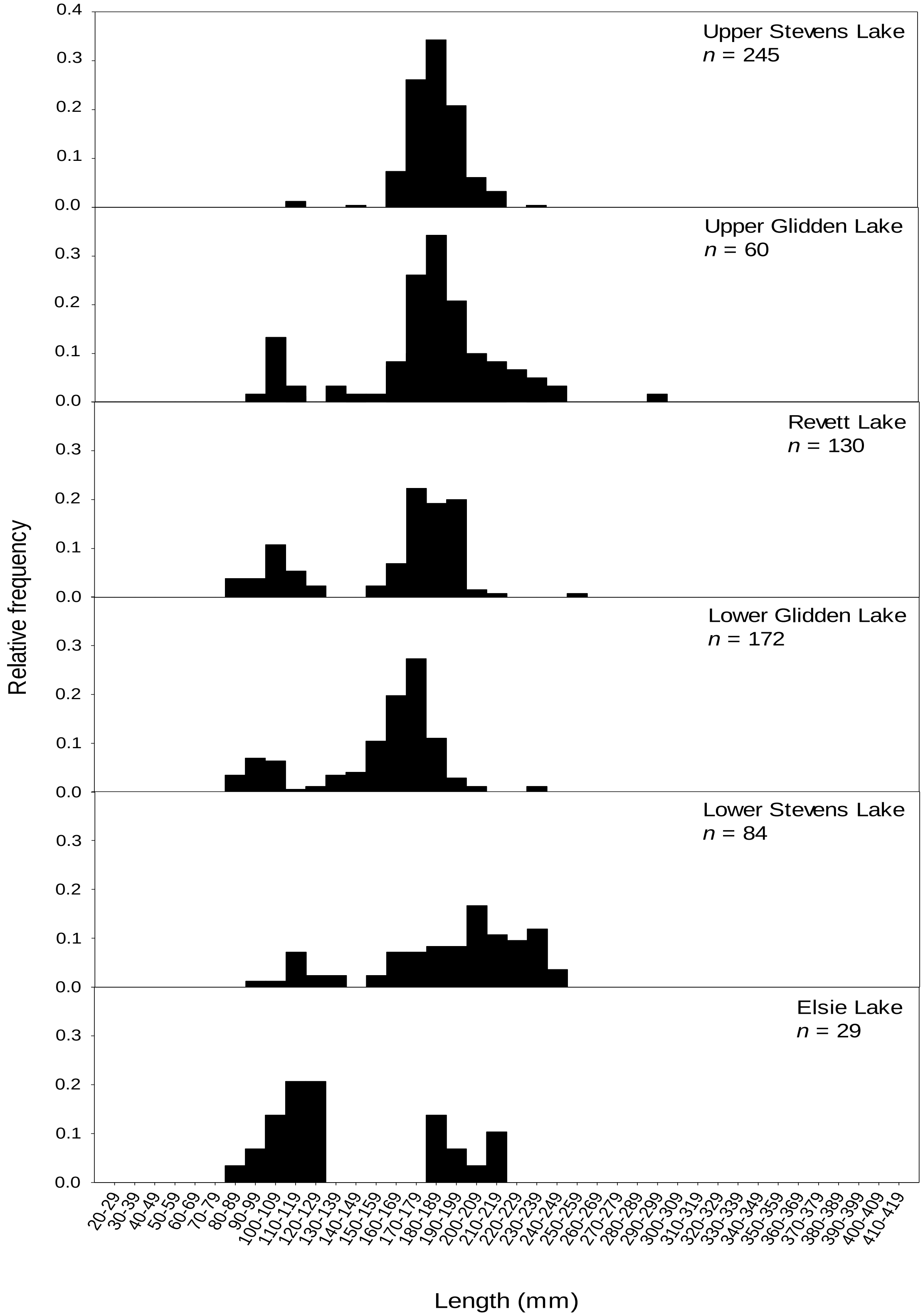

Figure 62. Length-frequency distributions for Brook Trout sampled from alpine lakes in the Spokane River Drainage (2014).

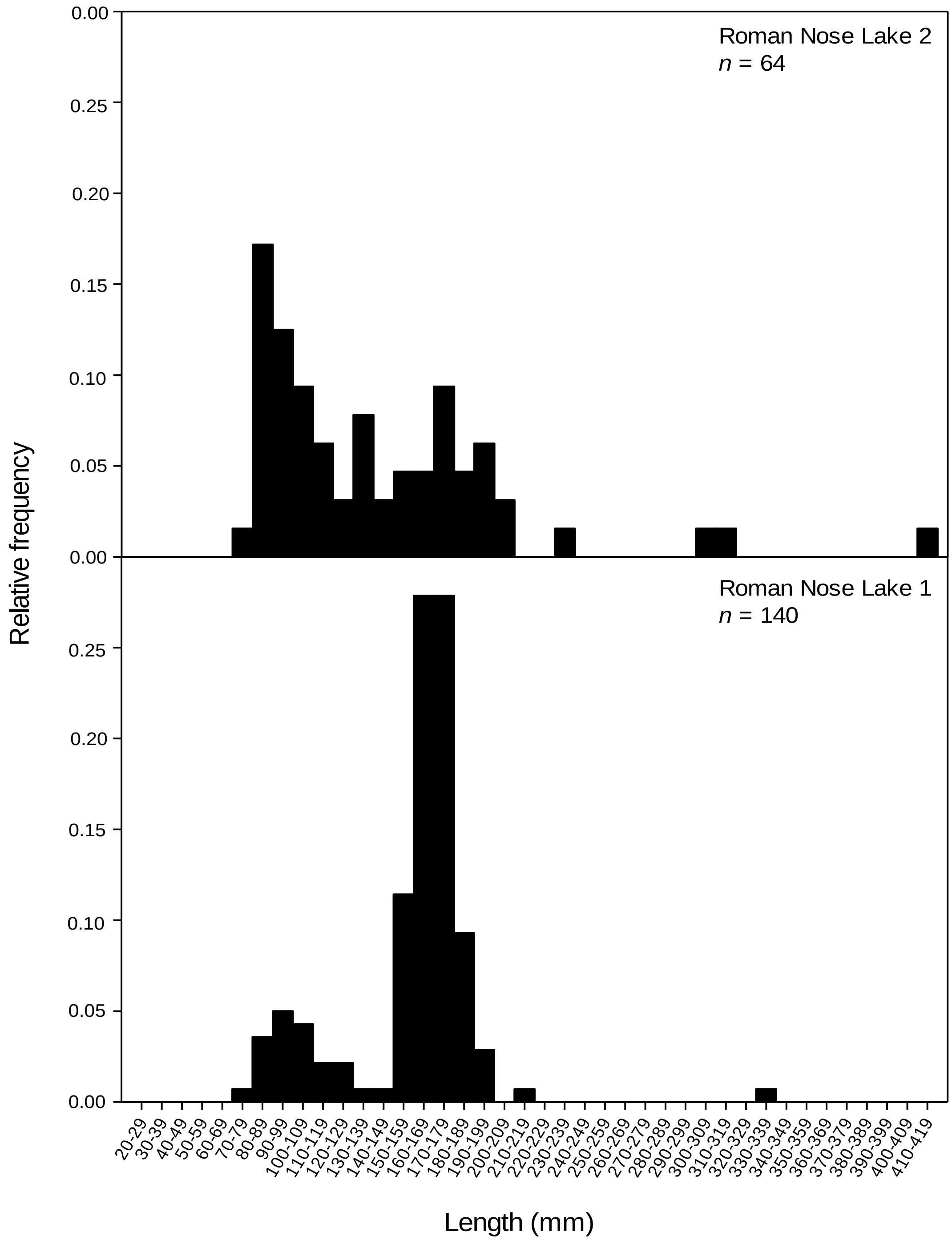

Figure 63. Length-frequency distributions for Brook Trout sampled from alpine lakes in the Kootenai River Drainage (2014).

SPOKANE BASIN WILD TROUT MONITORING

ABSTRACT

Long-term data from historical snorkeling transects have been critical for informing management of wild salmonids in the upper Spokane River Basin over the past several decades. In the Coeur d'Alene River and St. Joe River, maintenance of long-term datasets has allowed the Idaho Department of Fish and Game to document responses of Westslope Cutthroat Trout *Oncorhynchus clariki lewisi* to environmental conditions, habitat rehabilitation, and angling regulations. During August 4–15, 2014, we used daytime snorkeling to observe fishes in historical sampling transects in the Coeur d'Alene River (*n* = 44) and St. Joe River (*n* = 35) basins. We estimated total Westslope Cutthroat Trout densities of 1.17 fish/100 m^2 in the North Fork Coeur d'Alene River (including Teepee Creek), 1.97 fish/100 m^2 in the Little North Fork Coeur d'Alene River, and 1.83 fish/100 m^2 in the St. Joe River. For Westslope Cutthroat Trout ≥ 300 mm in total length, we estimated densities of 0.34 fish/100 m^2 in the North Fork Coeur d'Alene River, 0.51 fish/100 m^2 in the Little North Fork Coeur d'Alene River, and 0.60 fish/100 m^2 in the St. Joe River. Densities of Rainbow Trout *O. mykiss* remained at relatively low abundances in both drainages, and were similar to estimates from the past fifteen years, except in the Little North Fork Coeur d'Alene River where we observed higher densities of Rainbow Trout than we have in the past 23 years. Overall, trends in abundance and size structure of Westslope Cutthroat Trout in the upper Spokane River Basin have increased substantially over the past decade and continue to improve. Non-consumptive (i.e., catch-and-release) angling regulations have been an important factor contributing to the improved population status of Westslope Cutthroat Trout. Future monitoring should continue in order to better inform management of Westslope Cutthroat Trout and to demonstrate progress toward conservation objectives. Current catch-and-release angling regulations for Westslope Cutthroat Trout and liberal harvest regulations for non-native salmonids (i.e., Rainbow Trout, Brook Trout *Salvelinus fontinalis*) appear to be effective methods for maintaining good abundance and size structure of Westslope Cutthroat Trout populations.

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INTRODUCTION

Westslope Cutthroat Trout *Oncorhynchus clarkia lewisi* is one of 14 subspecies of Cutthroat Trout *O. clarki* native to North America. The native distribution of Westslope Cutthroat Trout is the most widespread of the 14 subspecies spanning both sides of the Continental Divide (Behnke 1992; Behnke 2002).Their native distribution west of the Continental Divide includes the Salmon River and its tributaries as well as all major drainages throughout the Idaho Panhandle. Despite their widespread distribution, declines in occurrence and abundance of Westslope Cutthroat Trout have been documented throughout their native range (Shepard et al. 2005).In fact, Westslope Cutthroat Trout now only occupy approximately 50% of their historic range in Idaho (Wallace and Zaroban 2013).Populations of Westslope Cutthroat Trout have been negatively influenced for a variety of reasons. Extensive land- and water-development activities which have reduced available instream habitat and altered flows and thermal regimes have negatively affected Westslope Cutthroat Trout to a great degree (Peterson et al. 2010). Another important factor related to range and abundance reductions has been interaction with nonnative salmonids (i.e., Rainbow Trout *O. mykiss* and Brook Trout *Salvelinus fontinalis*), with which they often compete and hybridize (Rainbow Trout only) (Marnell 1988; Allendorf et al. 2004; Shepard et al. 2005; Muhlfeld et al. 2009).

Concerns about the status of Westslope Cutthroat Trout have resulted in two petitions for listing under the U.S. Endangered Species Act (ESA 1973, as amended) in 1997 and 2001.Subsequent evaluations of extant populations determined that the relatively broad distribution and continued presence of isolated populations in Oregon, Washington, and Canada did not warrant protection under the ESA (U.S. Federal Register 1998, 2003). However, the U.S. Forest Service and Bureau of Land Management regard Westslope Cutthroat Trout as a sensitive species, and the Idaho Department of Fish and Game (IDFG) has designated it as a Species of Greatest Conservation Need (IDFG 2006; IDFG 2013). Due to their importance as a recreational, cultural, and socioeconomic resource, the IDFG has intensely managed Westslope Cutthroat Trout populations for both general conservation and to provide quality angling opportunities.

The Spokane River Basin represents one of the most important areas for Westslope Cutthroat Trout conservation in Idaho and the Pacific Northwest; specifically, because major tributaries to the Spokane River (i.e., Coeur d'Alene River and St. Joe River) provide strongholds for this sensitive species (DuPont et al. 2009; Stevens and DuPont 2011). In addition, Westslope Cutthroat Trout populations in the upper Spokane River Basin support important recreational fisheries. The close proximity of the Coeur d'Alene River and St. Joe River to large communities (i.e., Coeur d'Alene, Spokane, Missoula) makes these waters popular destination trout waters, and angling pressure has increased in recent times (Fredericks et al. 1997; DuPont et al. 2009).

Over the past century, Westslope Cutthroat Trout angling regulations have become increasingly conservative with a shift towards reducing harvest (Hardy et al. 2009; Kennedy and Meyer 2015). For example, prior to 2008 the lower portions of the Coeur d'Alene River (Lake Coeur d'Alene to confluence of Yellow Dog Creek) and St. Joe River (Lake Coeur d'Alene to North Fork St. Joe River) were managed under a 2-fish daily bag and slot limit (none between 203–406 mm; Hardy et al. 2009). However, currently the entire Spokane River Basin within Idaho is managed under a catch-and-release regulation for Westslope Cutthroat Trout, with the exception of the St. Maries River (2-fish daily bag limit). The shift to catch-and-release improved the population; however, increased education, enforcement of regulations, and habitat rehabilitation have also contributed. Westslope Cutthroat Trout populations responded very positively to regulation changes and angler use followed suit. Improvements in the quality of the fishery, combined with the elimination of season restrictions increased angler use in the Coeur d'Alene River and St. Joe River (IDFG 2013). In fact, an economic survey of angler use estimated that the number of angler trips increased from 35,000 in 2003 to 50,000 in 2011 (IDFG 2013). Continued monitoring has been tremendously important for formulating effective management plans for conservation of Westslope Cutthroat Trout in Idaho. Standardized monitoring has allowed IDFG to evaluate population-level responses to environmental change and management activities (Copeland and Meyer 2011; Kennedy and Meyer 2015), and thus improve the quality of the fishery in the Spokane River Basin.

OBJECTIVES

1. Monitor trends in abundance, distribution, and size structure of wild salmonids in the upper Spokane River Basin, with focus on Westslope Cutthroat Trout populations.

2. Monitor fish assemblage structure and species distribution to identify shifts in community assembly and occurrence patterns of native and non-native fishes alike.

3. Maintain long-term data to provide information related to factors affecting Westslope Cutthroat Trout abundance at broad spatial and temporal scale.

STUDY AREA

The Coeur d'Alene and St. Joe rivers are the largest tributaries to Lake Coeur d'Alene and the combination of these two drainages comprise ~ 50% of the greater Spokane River watershed. Both rivers originate in the Bitterroot Mountains along the Idaho-Montana border and are greatly influenced by spring runoff and snowmelt. Approximately 90% of the land area within the drainages is publically-owned by the U.S. Forest Service (Strong and Webb 1970). Dominant land-use practices in both drainages include hard rock and placer mining and extensive timber harvest (Strong and Webb 1970; Quigley 1996; DEQ 2001). While the combination of these activities has negatively influenced instream habitat and water quality, increased oversight and regulation of land-use has improved environmental conditions for native fishes in both the Coeur d'Alene and St Joe. River drainages (DEQ 2001).

Historic sampling reaches were established on the Coeur d'Alene River in 1973 (*n* = 42; Figure 64; Bowler 1974) and St Joe River in 1969 (*n* = 35; Figure 65; Rankel 1971; Davis et al. 1996). Sampling has been conducted on an annual basis for each reach since the beginning of the monitoring program with the exception of 7 reaches added to the St. Joe River in 1996 (Davis et al. 1996). Sampling reaches in the St. Joe River drainage occur only along the mainstem St. Joe River, while reaches within the Coeur d'Alene River drainage occur on the North Fork Coeur d'Alene River, Little North Fork Coeur d'Alene River, and Teepee Creek (Figure 64).

METHODS

Standardized index reaches in the North Fork of the Coeur d'Alene, Little North Fork Coeur d'Alene, and St. Joe rivers were sampled during August 4–15 using daytime snorkeling (DuPont et al. 2009; Thurow 1994). One (wetted width ≤ 10 m wide) or two (wetted width ≥ 10 m wide) observers slowly snorkeled downstream identifying fishes to species and estimating total length (TL; inches) of all salmonid species. Transects have been permanently marked with a global positioning system (GPS) and digital photographs provided reference to the upper and lower terminus of each reach. Estimates of salmonid abundance was limited to age-1+ fish, as summer counts for young-of-year (YOY) cutthroat and Rainbow Trout are typically unreliable. After completion of each sampling reach, each species was enumerated and salmonid species (i.e., Westslope Cutthroat Trout; Rainbow Trout; Mountain Whitefish [*Prosopium williamsoni*]) were separated into 75-mm length groups. Nongame fish species (e.g., *Cottus* spp. and *Catostomus* spp.) were enumerated, but lengths were not estimated.

Reach length and wetted width were measured at each sampling site with a laser rangefinder. The habitat type (pool, riffle, run, glide, pocket water), maximum depth, dominant cover type and amount of cover (estimated as % of surface area) in the area sampled was measured to assess if changes in habitat were responsible for any changes in fish abundance and assemblage structure. Surface area (m^2) was estimated at each site to provide a measure of sampling effort. The number of salmonids observed was divided by the surface area sampled to provide a standardized relative abundance measure. We calculated a mean relative density that could be compared to previous years (DuPont et al. 2009). Non-target species were enumerated and reported as the total number observed.

RESULTS

North Fork Coeur d'Alene River

A total of 1,356 Westslope Cutthroat Trout, 285 Rainbow Trout, and 5,027 Mountain Whitefish was observed among the 44 sampling sites in the North Fork Coeur d'Alene River drainage. In addition, we observed 60 Largescale Sucker *Catostomus macrocheilus*, 706 Northern Pikeminnow *Ptycholcheilus oregonsis*, 25 Redside Shiner *Richardsonius balteatus*, 30 kokanee *O. nerka*, and 12 Brook Trout. Mean total density of Westslope Cutthroat Trout was 1.17 fish/100 m^2 in the North Fork Coeur d'Alene River (including Teepee Creek) and 1.97 fish/100m^2 in the Little North Fork Coeur d'Alene River (Figure 66). Mean density of Westlope Cutthroat Trout ≥ 300 mm was 0.34 fish/100 m^2 in the North Fork Coeur d'Alene River and 0.51 fish/m^2 in the Little North Fork Coeur d'Alene River (Figure 67). Mean total density of Rainbow Trout in the North Fork Coeur d'Alene River was 0.18 fish/100 m^2 and 0.87 fish/100m^2 in the Little North Fork Coeur d'Alene River (Figure 68). Mean total density of Mountain Whitefish was 3.89 fish/100 m^2 in the North Fork Coeur d'Alene River and 0.3 fish/100 m^2 in the Little North Fork Coeur d'Alene River (Figure 69).

St. Joe River

A total of 1,022 Westslope Cutthroat Trout, 30 Rainbow Trout, and 1,419 Mountain Whitefish was observed among the 35 sampling sites in the St. Joe River. In addition, we observed 378 Largescale Sucker, 482 Northern Pikeminnow, 151 kokanee, and 1 Bull Trout *S. confluentus*. Unlike the Coeur d'Alene River, no Brook Trout or Redside Shiners were observed in the St. Joe River. Mean total density of Westslope Cutthroat Trout was 1.83 fish/100 m^2 (Figure 70). Mean density of Westlope Cutthroat Trout ≥ 300 mm was 0.60 fish/100 m^2 (Figure 71). Mean total density of Rainbow Trout and Mountain Whitefish was 0.01 fish/ 100 m^2 and 1.19 fish/100 m^2, respectively (Figure 72; Figure 73). In general, size structure of Westslope Cutthroat Trout in the St. Joe River (RSD-300 = 64.80) was better than in the Coeur d'Alene River Basin (RSD-300 = 51.17; Figure 74).

DISCUSSION

The upper Spokane River Basin represents one of Idaho's most important systems for conservation of Westslope Cutthroat Trout. Previous work on Westslope Cutthroat Trout has shown that declines in abundance and size structure in both the Coeur d'Alene River and St. Joe River were directly related to overexploitation and habitat degradation (Rankel 1971; Mink et al. 1971; Lewynsky 1986). However, in the Spokane River Basin and elsewhere in Idaho, Westslope Cutthroat Trout populations have positively responded to changes in angling regulations and habitat quality.

Westslope Cutthroat Trout densities have increased markedly since the beginning of this monitoring program and continue to show improvement (Maiolie and Fredericks 2014). Although we have documented a considerable amount of variability in annual density estimates, the past decade is characterized by the highest densities in both the North Fork Coeur d'Alene River and St. Joe River. In particular, increased densities of Westslope Cutthroat Trout ≥ 300 mm have reflected substantial improvements in size structure. We continue to see increases in Mountain Whitefish densities in the lower portions of the Coeur d'Alene River and St. Joe River. Rainbow Trout densities remain at extremely low abundance throughout the St. Joe River and North Fork Coeur d'Alene River. We did, however, document an increase in Rainbow Trout density in the Little North Fork Coeur d'Alene River. Notwithstanding, Westslope Cutthroat Trout densities continue to show signs of improvement in the Little North Fork Coeur d'Alene River. Also, given the high degree of variability surrounding this estimate, we do not believe that this slight increase is cause for concern or reflects what may become a dramatic increase in Rainbow Trout abundance in the system. Rainbow Trout are known to compete and hybridize with Westslope Cutthroat Trout and the IDFG manages for low abundance of Rainbow Trout in the Spokane River Basin to reduce the potential for such interactions.

MANAGEMENT RECOMMENDATIONS

1. Continue to monitor wild trout abundance and population characteristics in the upper Spokane River Basin.

2. Continue to monitor trends in fish assemblage characteristics.

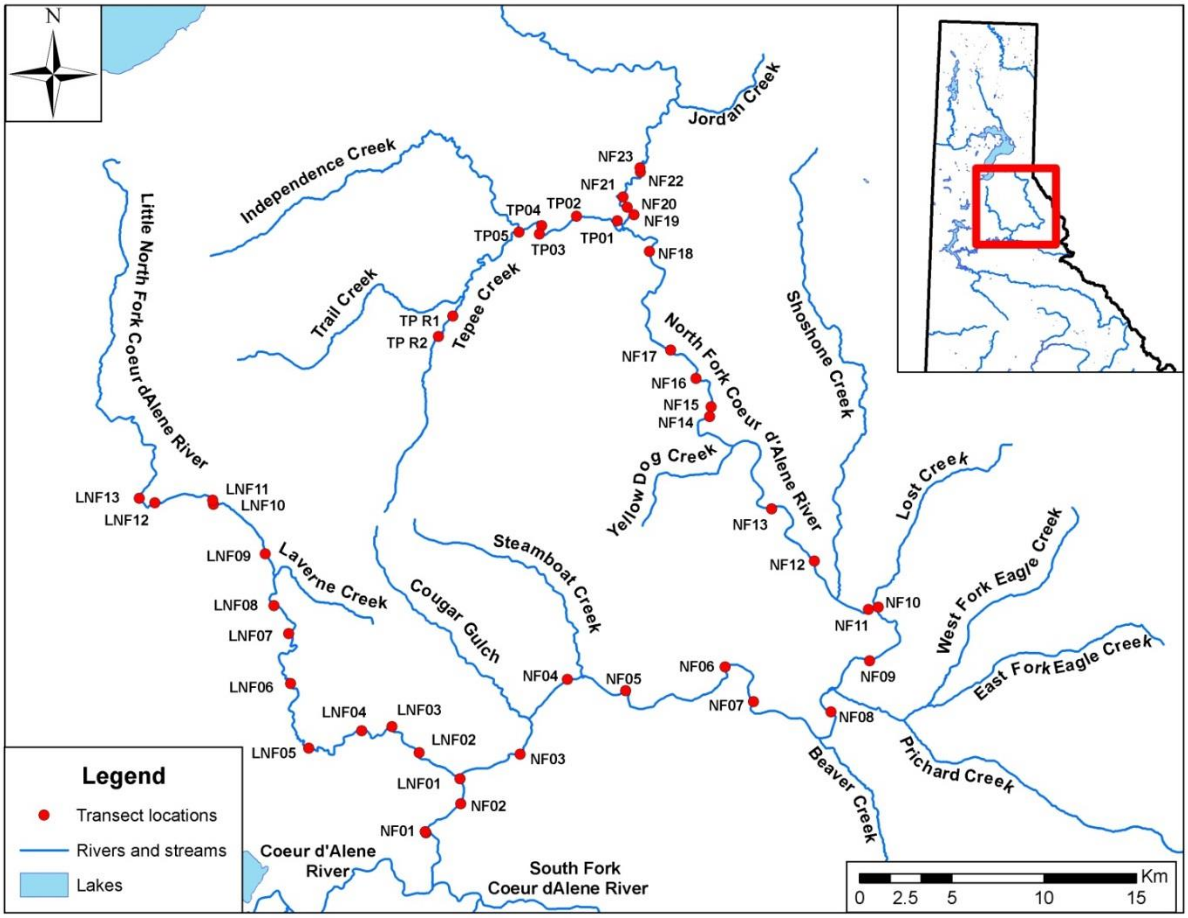

Figure 64. Location of 42 index reaches sampled using snorkeling in the Coeur d'Alene River, Idaho during August 11–15, 2014.

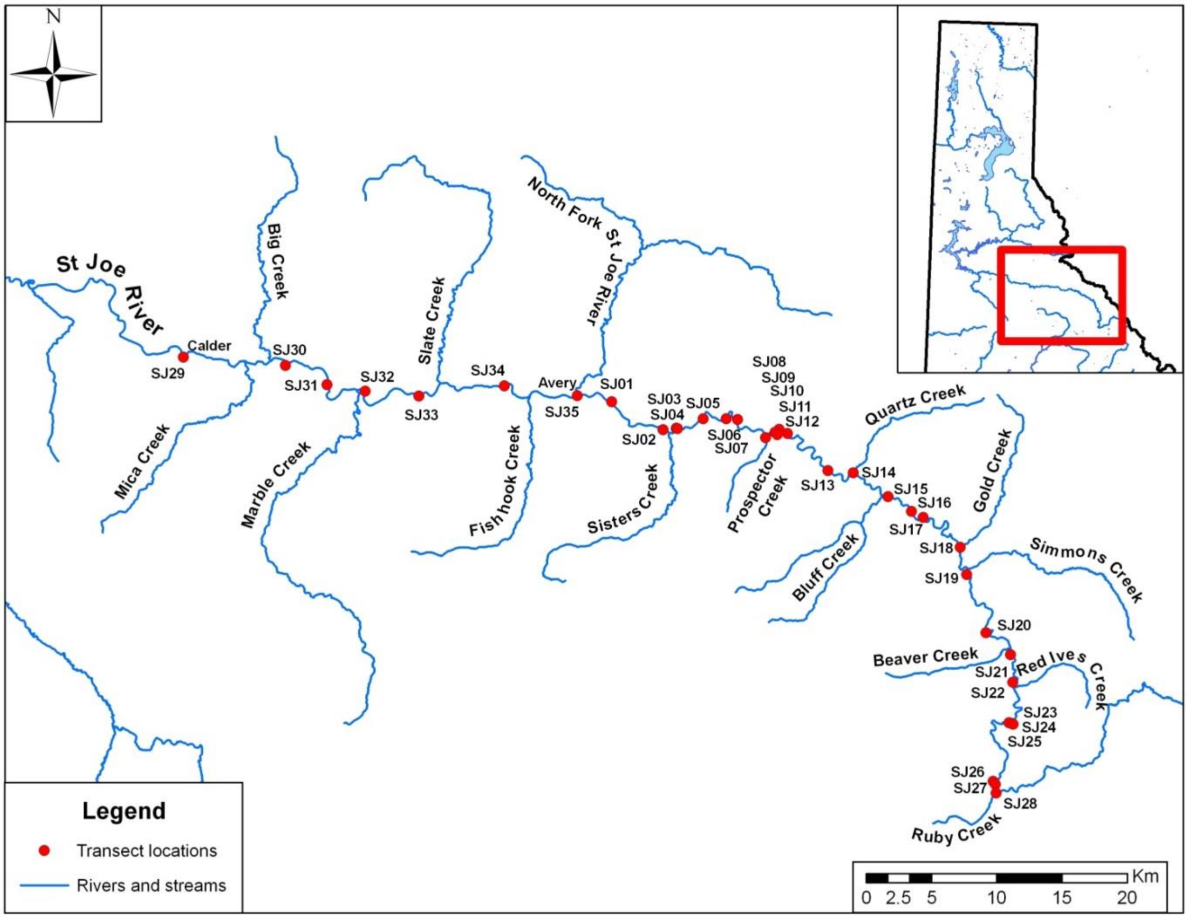

Figure 65. Location of 35 index reaches sampled using snorkeling in the St. Joe River, Idaho during August 4–7, 2014.

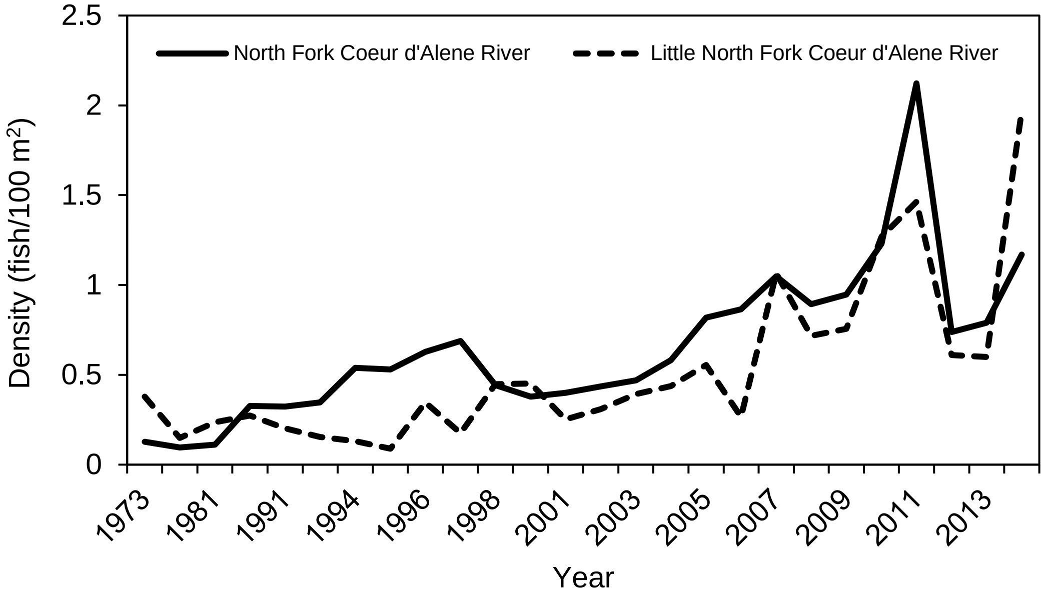

Figure 66. Mean density of Westslope Cutthroat Trout observed during snorkeling in the North Fork of the Coeur d'Alene River and Little North Fork of the Coeur d'Alene River (1973–2014).

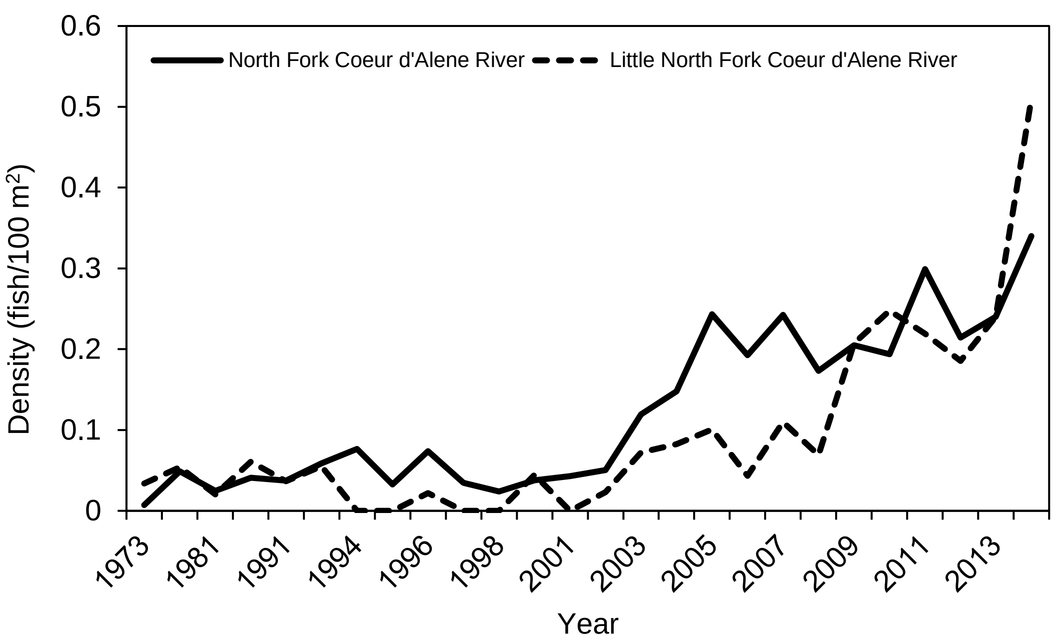

Figure 67. Mean density of Westslope Cutthroat Trout larger than 300 mm TL observed during snorkeling in the North Fork of the Coeur d'Alene River and Little North Fork of the Coeur d'Alene River (1973–2014).

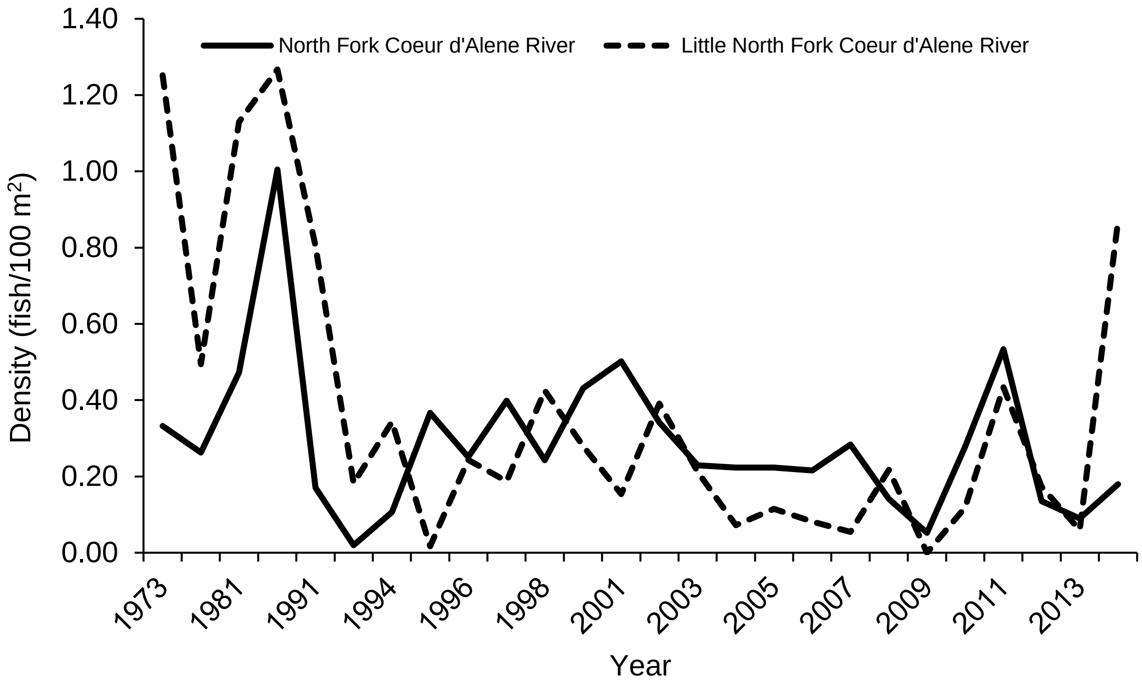

Figure 68. Mean density of Rainbow Trout observed during snorkeling in the North Fork of the Coeur d’Alene River and Little North Fork of the Coeur d’Alene River (1973–2014).

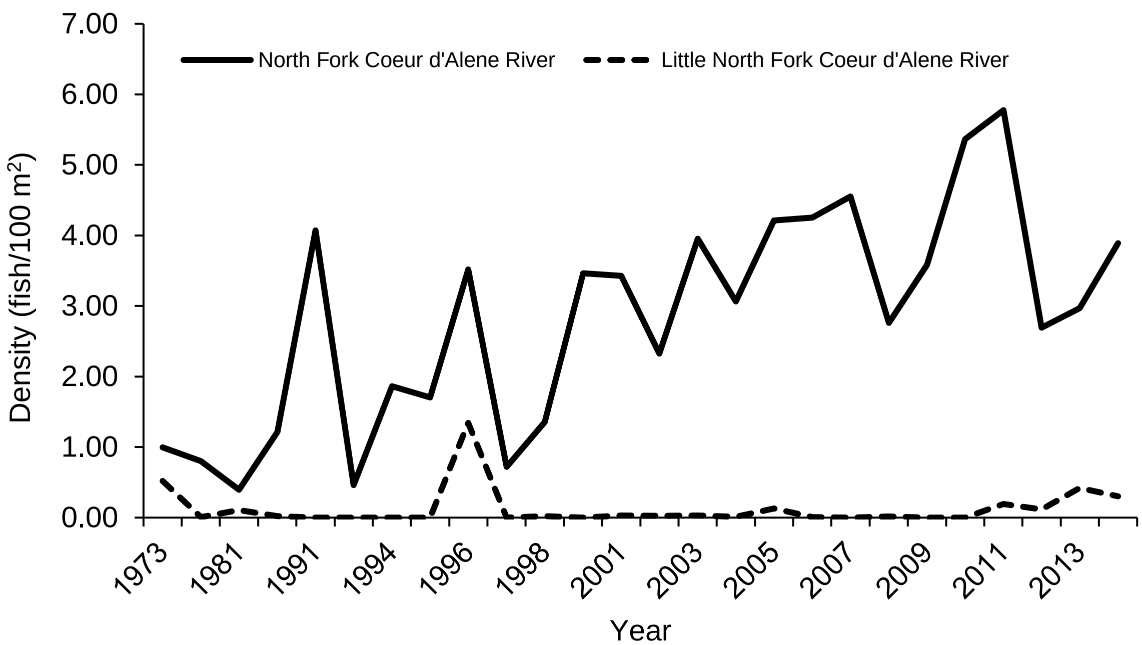

Figure 69. Mean density of Mountain Whitefish observed during snorkeling in the North Fork of the Coeur d’Alene River and Little North Fork of the Coeur d’Alene River (1973–2014).

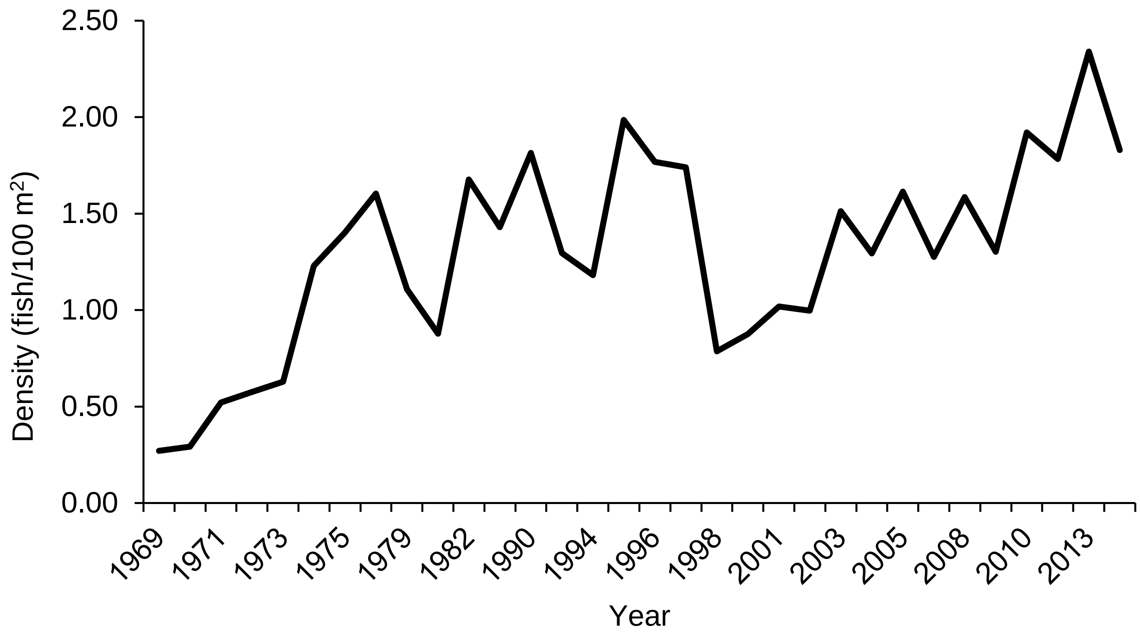

Figure 70. Mean density of Westslope Cutthroat Trout observed during snorkeling in the St. Joe River (1969–2014).

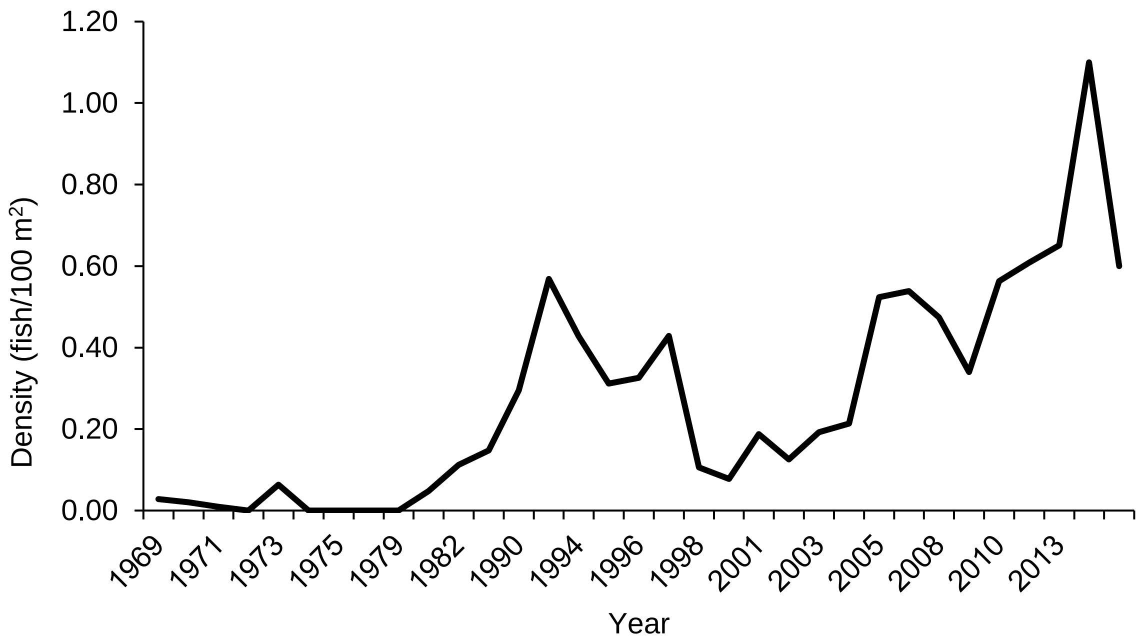

Figure 71. Mean density of Westslope Cutthroat Trout larger than 300 mm TL observed during snorkeling in the St. Joe River (1969–2014).

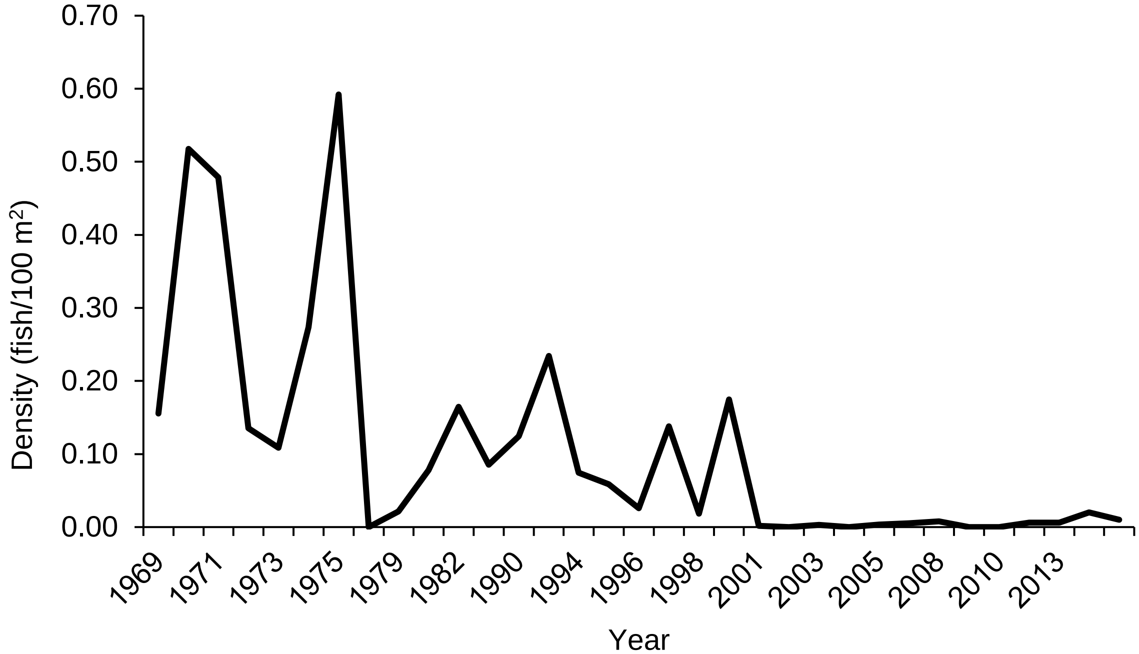

Figure 72. Mean density of Rainbow Trout observed during snorkeling in the St. Joe River (1969–2014).

Figure 73. Mean density of Mountain Whitefish observed during snorkeling in the St. Joe River (1969–2014).

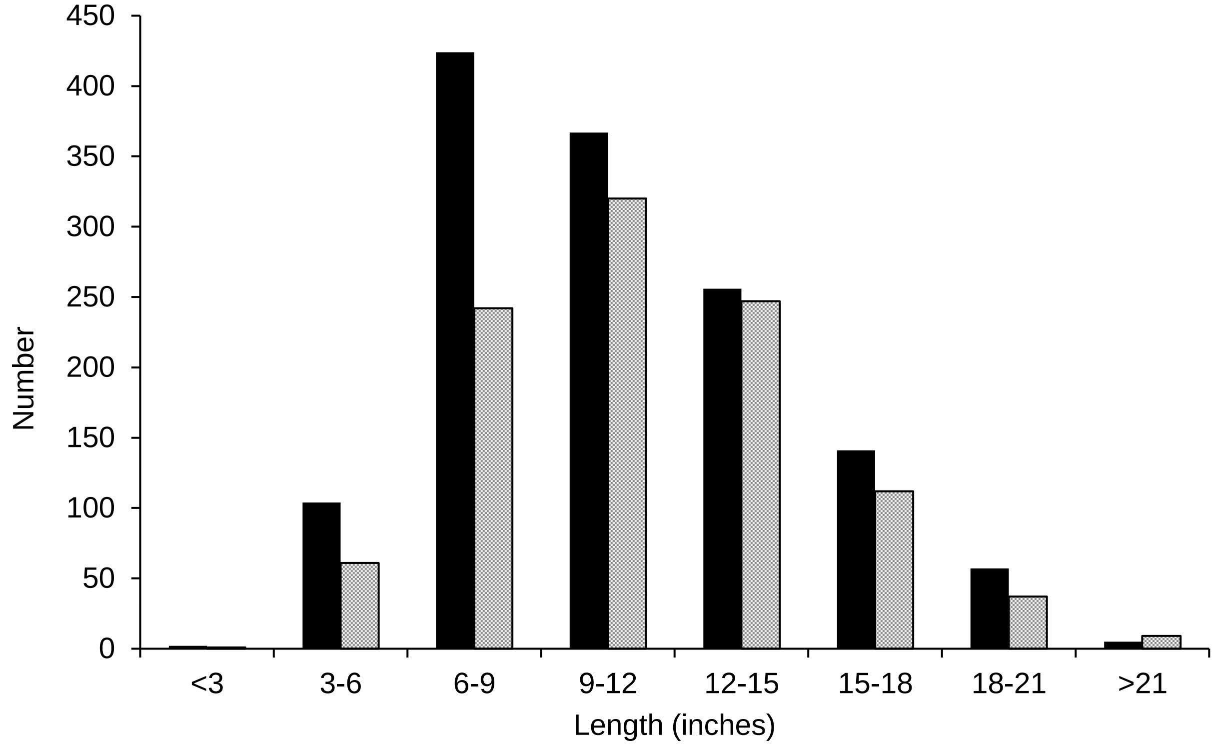

Figure 74. Length-frequency distributions of Westslope Cutthroat Trout observed during snorkeling in the North Fork Coeur d'Alene River (includes Little North Fork Coeur d'Alene River and Teepee Creek; black bars) and St. Joe River (gray bars) during 2014.

BULL TROUT REDD COUNTS

ABSTRACT

In 2014, we counted Bull Trout redds as an index of adult abundance in each of the major drainages in northern Idaho's Panhandle Region. Bull Trout redd surveys detected a total of 820 redds, including; 715 in the Pend Oreille drainage, 81 redds in the Upper Priest Lake drainage, 17 in the St. Joe drainage, and 7 in the Kootenai River drainage. Redd count totals from 2014 represented both increases and declines relative to averages of count totals from the previous ten-year periods, but did not reflect dramatic shifts in count abundance in any core area.

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INTRODUCTION

Bull Trout *Salvelinus confluentus* were listed by the U.S. Fish and Wildlife Service (USFWS) as a threatened species under the Endangered Species Act in 1999. Idaho Department Fish and Game (IDFG) personnel, along with employees of other state and federal agencies, annually count Bull Trout redds in some of the core recovery areas to monitor long-term trends of these populations. Redd counts allow for evaluation of the status of the populations in these areas and to help in directing future management and recovery activities.

STUDY SITES

Bull Trout redds were counted in headwater streams within the Priest River, Pend Oreille Lake, Kootenai River, and St. Joe River drainages where Bull Trout were known to spawn. These watersheds make up all or part of four different core areas that occur in the IDFG Panhandle Region. The boundaries of the Kootenai River core area extends outside of the Panhandle Region so our counts represent only a small portion of the population in these core areas.

METHODS

We counted Bull Trout redds in selected tributaries of the Priest Lake, Priest River, Pend Oreille Lake, Kootenai River, and St. Joe River where Bull Trout were known or believed to occur. We summarized counts by basins or core area. Redd counts in the Middle Fork (MF) East River and Uleda Creek (tributaries of Priest River) were combined with the Pend Oreille Lake Core Area in 2003 when these Bull Trout were documented to spend their adult life in Pend Oreille Lake (Dupont et al. 2009).

We located redds visually by walking along annually monitored sections within each tributary. Bull Trout redds were defined as areas of clean gravels at least 0.3 x 0.6 m in size with gravels of at least 76.2 mm in diameter having been moved by the fish, and with a mound of loose gravel downstream from a depression (Pratt 1984). In areas where one redd was superimposed over another redd, each distinct depression was counted as one redd. Redd surveys were conducted during the standardized time periods (late September/ October). In some surveys redd locations were recorded on maps and/or recorded by global positioning system (GPS).

We compared Bull Trout redd count totals by core area to prior count years to assess dramatic shifts in redd abundance. Total redd counts were compared to average counts from the previous ten years of sampling. Comparisons were generally qualitative references to increases or declines relative to previous count averages.

RESULTS AND DISCUSSION

Pend Oreille Core Area

We completed Pend Oreille core area redd counts between October 9 and 23, 2014. A total of 715 Bull Trout redds were counted among all surveyed streams (Table 23). Six index streams counted consistently since 1983 accounted for 369 of the total redds. Overall counts were below the previous ten-year averages for total and index counts of 804 and 523, respectively.

Priest Lake Core Area

We completed Priest River core area redd counts on September 29, 2014. We counted 81 Bull Trout redds between seven standard (defined in 2013) stream reaches surveyed in the core area (Table 24). Overall counts increased from the previous year and were above the previous ten-year average for combined counts of 32 redds.

St Joe Core Area

St Joe River core area redd counts were completed between September 22–30, 2014. We counted a total of 17 Bull Trout redds among eight surveyed streams in the core area (Table 25). Index streams (i.e., Wisdom Creek, Medicine Creek, and mainstem St. Joe River [between Heller Creek and St. Joe Lake]) accounted for all of the redds observed. In addition, all of the redds we observed occurred in Medicine Creek. Index and total counts represented a decline from previous years and from the previous ten-year average for index streams.

The number of streams surveyed per year in the St Joe River core area has varied considerably over time. Interpretation of total count values should be done cautiously. We recommend focusing future efforts primarily on index streams to better understand trends in redd abundance.

Kootenai River Core Area

Kootenai River core area redd counts were completed on Idaho tributary streams in October 2014. A total of seven Bull Trout redds were observed between two surveyed streams in Idaho (Table 26). Additional Bull Trout redd surveys were completed within Montana tributaries to the Kootenai River, but were not reported here. Idaho Bull Trout surveys continue to represent a small proportion of the total redds observed in the Kootenai system.

MANAGEMENT RECOMMENDATIONS

1. Continue to monitor Bull Trout spawning escapement through completion of redd surveys.

2. Continue to balance the frequency and location of surveys with the availability of time and intended use of collected data.

Table 23. Bull Trout redd counts by year from tributaries of Lake Pend Oreille, Clark Fork River, and Pend Oreille River, Idaho.

Stream (*Index)	Avg 1983-2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Clark Fork R.	7	0	3	2	0	1	0	0	--	--	--
Lightning Cr.	10	22	9	3	10	11[b]	0	20	1	1	4
East Fork Cr. *	51	50	51	34	38	85	26	64	11[b]	26	22
Savage Cr.	8	7	25	0[b]	8	5	6	1	--[b]	5	6
Char Cr.	11	15	20	1	5[d]	1[d]	4[d]	9[d]	0[b,d]	4[d]	2[d]
Porcupine Cr.	9	14	8	8	8	15	11	13	2[b]	4	15
Wellington Cr.	9	6	29	9	10	4[b]	7	6	5	5	11
Rattle Cr.	22	34	21	2	24	62[b]	43	65	59	8	63
Johnson Cr. *	19	45	28	32	40	47	57	54	54	50	21
Twin Cr.	9	7	11	0	4	0	0	1	--	--	--
Morris Cr.	2	3	16	0	6	6	9	0	0[b]	3	14
Strong Cr.	1	--	--	--	7	6	2	11	3	47	17
Trestle Cr. [a] *	251	174	395	145	183	279	188	178	187	133	159
Pack R.	23	53	44	16	11	4	0	1	7	6	1
Grouse Cr. *	37	77	55	38	31	51	27	116	69	12	54
Granite Cr.	43	132	166	104	52	106[c]	75[c]	129[c]	68	217	115
Sullivan Springs Cr.	15	15	28	17	7[c]	2[c]	9[c]	11[c]	4	11	4
North Gold Cr. *	30	34	30	28	17	28[c]	28[c]	6[c]	3[b]	28	25
Gold Cr. *	120	200	235	179	73	107[c]	130[c]	56[c]	110[c]	106[c]	88
W.Gold Cr.	NA	--	4	0	7	5	4	0	8	29	10
M.F. East R.	13	48	71	34	36	25	22	28	28	25	51
Uleda Cr.	4	4	7	2	7[b]	16	6	9	24	14	26
N.F. East R.	1	0	0	--	0	--	0	--	--	--	--
Caribou Creek	NA	--	--	--	--	--	--	37	6	47	9
Hellroaring	NA	--	--	--	--	--	--	--	3	--	--

Total 6 index streams	507	580	794	456	382	597	456	474	434	355	369
Total of all streams	694	940	1256	654	584	866	654	815	652	781	715

[a] Additional apprx. 0.5 km reach immediately upstream of index reach on Trestle Creek added in 2001
[b] Impaired observation conditions (ice, high water, ect)
[c] Abundant early spawning kokanee made identification of Bull Trout redds in lower reaches difficult
[d] Barrier excluded Bull Trout from accessing typical spawning habitat

Table 24. Bull Trout redd counts by year from the Upper Priest River, Idaho and selected tributaries between 1993 and 2014. Redd surveys were not completed on all stream reaches in all years between 1993 and 2003. As such, averaged redd counts for surveys completed between these years may include fewer completed counts.

Stream	Transect Description	Length (km)	Avg. 1993 -2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Upper Priest River	Falls to Rock Cr.	12.5	12	13	21	5	14	5	17	10	36	34	58
	Rock Cr. to Lime Cr.	1.6	2	0	1	0	0	2	4	1	0	7	8
	Lime Cr. to Snow Cr.	4.2	7	3	4	1	5	10	3	1	3	6	9
	Snow Cr. to Hughes Cr.	11.0	4	10	0	1	2	4	0	7	2	2	0
	Hughes Cr. to Priest Lk	2.3	0	--	--	--	--	--	0	0	0	--	--
Rock Cr.	Mouth to F.S. trail 308	0.8	> 1	0	0	0	0	0	1	0	0	--	--
Lime Cr.	Mouth upstream 1.2 km	1.2	> 1	0	0	0	0	0	0	0	0	--	--
Cedar Cr.	Mouth upstream 3.4 km	3.4	> 1	0	0	0	0	0	0	0	0	--	--
Ruby Cr.	Mouth to waterfall	3.4	0	0	--	0	0	0	0	--	--	--	--
Hughes Cr.	Trail 311 to trail 312	2.5	1	0	0	0	0	0	0	0	0	--	--
	F.S. road622 to Trail 311	4.0	1	1	1	0	0	5	0	7	5	0	3
	F.S. road 622to mouth	7.1	2	1	1	0	0	3	11	3	2	1	2
Bench Cr.	Mouth upstream 1.1 km	1.1	> 1	0	0	0	0	0	0	0	0	--	--
Jackson Cr.	Mouth to F.S. trail 311	1.8	0	0	1	0	0	0	0	0	0	--	--
Gold Cr.	Mouth to Culvert	3.7	3	1	0	0	1	5	6	2	4	3	1
Boulder Cr.	Mouth to waterfall	2.3	0	0	--	0	0	0	0	--	0	--	--
Trapper Cr.	Mouth upstream 5.0 km upstream from East Fork	5.0	2	0	--	0	0	0	0	--	0	--	--
Caribou Cr.	Mouth to old road crossing	2.6	> 1	--	--	--	--	--	0	--	--	--	--
All stream reaches combined		70.5	31	29	29	7	22	34	42	31	52	53	81

Table 25. Bull Trout redd counts by year from the St Joe River, Idaho and selected tributaries. Redd surveys were not completed on all stream reaches in all years between 1992 and 2003. As such, averaged redd counts for surveys completed between these years may include fewer completed counts.

Stream Name	Avg 1992 - 2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Aspen Cr.	0	--	--	--	--	--	--	--	--	--
Bacon Cr.	0	--	--	--	0	--	--	0	--	0
Bad Bear Cr.	0	--	--	--	--	--	--	--	--	--
Bean Cr.	7	--	--	--	1	--	--	1	0	--
North Fork Bean Creek	--	--	--	--	--	--	--	19	8	0
Unnamed tributary to N.Fk. Bean	--	--	--	--	--	--	--		3	--
Beaver Cr.	<1	0	0	0	0	3	--	0	--	--
Bluff Cr.- East Fork	0	--	--	--	--	--	--	--	--	--
California Cr.	1	0	0	0	2	--	--	0	--	--
Cascade Creek	--	--	--	--	--	--	--	2	--	--
Copper Cr.	0	--	0	0	--	--	--	--	--	--
Entente Cr.	<1	--	--	--	--	--	--	--	--	--
Fly Cr.	1	--	0	2	1	0	--	0	--	--
Gold Cr. Lower mile	0	--	--	--	--	--	--	--	--	--
Gold Cr. Middle	0	--	--	--	--	--	--	--	--	--
Gold Cr. Upper	1	--	--	--	--	--	--	--	--	--
Gold Cr. All	1	--	--	--	--	--	--	--	--	--
Heller Cr.	<1	5	0	0	3	9	5	5	--	0
Indian Cr.	0	--	--	--	--	--	--	--	--	--
Medicine Cr.*	28	71	55	71	41	48	35	20	20	17
Mill Cr.	--	--	--	--	--	--	--	9	6	--
Mosquito Cr.	1	--	--	--	--	--	--	--	--	--
My Cr.	--	--	--	--	--	--	--	0	--	--
Pole	--	--	--	--	--	--	--	0	--	--
Quartz Cr.	0	--	--	--	--	--	--	--	--	--
Red Ives Cr.	<1	0	1	1	--	2	4	0	--	0
Ruby Cr.	3	--	--	--	--	--	--	0	--	--
Sherlock Cr.	1	0	0	3	--	1	--	2	--	0
Simmons Cr. - Lower	0	--	--	1	0	--	--	--	--	--
Simmons Cr. - NF to Three Lakes	3	0	--	--	0	--	--	--	--	--
Simmons Cr. - Three Lakes to Rd 1278	2	0	--	--	0	--	--	--	--	--
Simmons Cr. - Rd 1278 to Washout	<1	--	--	--	0	--	--	--	--	--
Simmons Cr. - Upstream of Washout	0	--	--	--	0	--	--	--	--	--

Table 25. Continued.

Stream Name	Avg 1992 - 2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Simmons Cr. - East Fork	0	--	--	--	--	--	0	--	--	--	--	--
St. Joe River - below Tento Creek	0	--	--	--	--	--	--	--	--	--	--	--
St. Joe River - Spruce Tree CG to St. J. Lodge	0	--	--	--	--	--	--	--	--	--	--	--
St. Joe River - St. Joe Lodge to Broken Leg	4	--	--	--	--	--	--	--	--	--	--	--
St. Joe River - Broken Leg Cr upstream	0	--	--	--	--	--	--	--	--	--	--	--
St. Joe River - Bean to Heller Cr.	0	--	--	--	--	--	--	--	--	--	--	--
St. Joe River - Heller to St. Joe Lake*	9	9	10	0	6	8	1	5	7	4	1	0
Three Lakes Creek	0	--	--	--	--	--	--	--	--	--	--	--
Timber Cr.	<1	--	--	--	--	--	--	--	--	--	--	--
Tinear Cr.	--	--	--	--	--	--	--	--	--	2	5	--
Wampus cr	0	--	--	--	--	--	--	--	--	--	--	--
Washout cr.	1	--	--	--	--	--	--	--	--	--	--	--
Wisdom Cr*	5	11	19	12	32	27	8	1	1	5	1	0
Yankee Bar	<1	0	0	3	0	0	--	--	--	--	--	--
Total - Index Streams*	41	72	91	83	93	106	50	54	43	29	22	17
Total - All Streams	49	79	93	91	94	113	57	69	52	69	44	17
Number of streams counted	15	13	11	11	11	12	15	8	5	18	8	8

* Index streams

Table 26. Bull Trout redd counts by year from the selected tributaries of the Kootenai River in Idaho.

Stream	Length (km)	Avg 2002-2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
IDAHO												
North Callahan Creek	3.3	21	10	29	3	17	10	9	2	6	9	7
South Callahan Creek	4.3	7	5	4	0	0	0	1	0	0	2	0
Boulder Creek	1.8	1	1	0	0	0	0	0	0	0	0	--
Idaho Total	9.4	28	16	33	3	17	10	10	2	6	11	7

PRIEST LAKE ANGLER SURVEY

ABSTRACT

We conducted a year-long angler survey on Priest Lake between March 2, 2014 and February 28, 2015 to evaluate angler use and performance of the fishery. Instantaneous boat counts were conducted by airplane, while angler interviews were collected by creel clerks roving the lake. Boat count and angler interview data were used in combination to estimate angler effort and catch rates. We combined effort and catch rate metrics to estimate catch and harvest of targeted species. We estimated anglers fished 46,719 ± 2,990 (80% C.I.) hours during the survey period, representing 10,923 angler trips. Anglers primarily targeted Lake Trout (67% of effort) and kokanee (23% of effort). Targeted catch rates were highest for Smallmouth Bass (3.27/h), followed by Lake Trout (1.07/h), kokanee (0.94/h), and Westslope Cutthroat Trout (0.64/h). Angler harvest (± 80% C.I.) was highest for Lake Trout (10,787 ± 1,850), while kokanee (4,622 ± 1,319) and Smallmouth Bass (750 ± 681) were the only other species commonly harvested. Our survey demonstrated that angler effort has diversified on Priest Lake, potentially implying that anglers desire greater fishery diversity than has been present in recent decades. Notable changes in the Priest lake fishery included an increase in targeted kokanee fishing effort. We also observed, the fairly recent establishment of Smallmouth Bass in the lake led to anglers targeting this species for the first time and experiencing high catch rates. While total angler effort and total harvest in Priest Lake has historically been higher than during this survey period, anglers did experience some of the best fishing success documented for multiple species, with moderate to high catch rates for all primary species targeted.

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INTRODUCTION

Priest Lake is located in Idaho's panhandle about 28 km south of the Canadian border. Surface area of the lake is 9,446 ha. Historically, Priest Lake provided fisheries for Bull Trout *Salvelinus confluentus*, Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, and Mountain Whitefish *Prosopium williamsoni*. Introductions of kokanee *Oncorhynchus nerka*, Lake Trout *Salvelinus namaycush,* Largemouth Bass *Micropterus salmoides,* Smallmouth Bass *Micropterus dolomieu*, and Yellow Perch *Perca flavescens* created additional fishing opportunities that are present today (Liter et al. 2009). The Priest Lake fishery is economically important, with an estimated $5.9 million spent by anglers fishing the lake in 2011(IDFG, unpublished data).

Priest Lake fisheries management has changed significantly since the early 1900's in response to species introductions, social desires, and a variety of other factors. Two of the historically most targeted species by anglers, Bull Trout and Westslope Cutthroat Trout, have been regulated under a "no harvest" scenario since the late-1980's due to real or perceived declines in abundance. Kokanee once supported the primary fishery in the lake and offered significant harvest opportunity. However, kokanee abundance declined through the 1970's and 80's which resulted in a harvest closure. Kokanee densities in the lake remained low, but a harvest fishery was reopened in 2011 and has gained considerable interest among anglers (Fredericks et al. 2013). Historically, Lake Trout occurred at low density, but reached large sizes because of an abundant kokanee prey. Thus, Lake Trout once supported a popular trophy fishery. However, increased Lake Trout abundance from the 1970s to 90s led to changes in population dynamics and subsequent shifts in management direction including the current yield fishery (IDFG 2013). Smallmouth Bass are newly established in Priest Lake and gaining angler interest; thus, they may increasingly influence management decisions in the future.

Management of the Priest Lake fishery in recent decades has been heavily influenced by altered trophic dynamics following the introduction of mysid shrimp *Mysis diluviana* in the 1960s. Fish population responses in Priest Lake closely matched those observed in other western U.S waters after mysid introduction (Martinez et al. 2009). Mysid shrimp fueled the rapid growth of the Lake Trout population, which was followed by declines in other previously abundant fishes (i.e., kokanee, Bull Trout; IDFG 2013). Additionally, mysid shrimp may compete with kokanee (Chips and Bennet 2000, Spencer et al. 1991) for available zooplankton, although we do not know to what extent this has occurred in Priest Lake. Bull Trout, which were once abundant in the lake, are now nearly extirpated and absent in angler catches. The Bull Trout population in Upper Priest Lake is the exception, having remained relatively stable over the last two decades (see Bull Trout Redd Counts chapter in this report). Westslope Cutthroat Trout were believed to have declined in the Priest Lake system as early as the 1950s (Bjorn 1957). Unfortunately, early information regarding abundance was primarily verbal accounts by anglers and population monitoring has been extremely limited since that time, making comparisons difficult.

Current fishery management objectives for Priest Lake are independent of Upper Priest Lake. However, observations of fish movements through the Thorofare, approximately 3 km of flowing water between Upper Priest Lake and Priest Lake, clearly demonstrate the fish communities within the two lakes are not independent (Venard and Fredericks 2001). Current management priorities include a native species focus in Upper Priest Lake and a mixed species focus, including Lake Trout, kokanee, and Westslope Cutthroat Trout in Priest Lake. The connectivity of these water bodies precludes independent management of their fisheries, thus challenging our ability to meet the contrasting management objectives between lakes. In addition, Priest Lake anglers are currently divided between favoring management for Lake Trout or enhancement of other species (i.e., Westslope Cutthroat Trout, kokanee; IDFG 2013). To address these issues, the Idaho Department of Fish and Game Fisheries Management Plan 2013-2018 indicates a better understanding of the fish communities in this system is necessary to guide future management direction (IDFG 2013).

We completed an angler survey on Priest Lake in 2014-15 to evaluate angler use and performance of the fishery. As part of this survey, we estimated fishing effort, catch rates, and harvest occurring over a twelve-month time period. Survey results were used to describe fishery trends and evaluate the fishery response to ongoing management actions.

METHODS

We conducted a year-long creel survey on Priest Lake between March 2, 2014 and February 28, 2015 using an aerial-roving design (Pollock et al. 1994). The survey period was divided into 26 two-week intervals. Intervals were stratified by day type, including weekdays and weekend/holidays. We scheduled four boat counts per interval, consisting of two weekday counts and two weekend/holiday counts. Within each interval, the day and time of boat counts were randomly chosen. We coordinated boat counts with a creel survey being conducted on Lake Pend Oreille during the same year. Surveys were coordinated because the same flight service was used to conduct boat counts and flight cost savings achieved by combining surveys made the use of aircraft for boat counts possible.

Instantaneous counts were conducted by airplane in order to obtain rapid and accurate boat counts. Aerial counts of the number of boats actively fishing were completed by a pilot as a plane circled Priest Lake (intervals 2-26). Aerial counts were generally completed in the same directional pattern for each count, beginning at the southern end of the lake. Boats that were not actively fishing were excluded from the counts. Angler counts, rather than boat counts, were completed during interval one at access points from the ground by creel clerks. Ice covered Priest Lake during interval one and anglers were largely confined to only a few accessible locations. We initially used aerial counts to survey shore anglers, in addition to boats. We discontinued shore angler counts because few shoreline anglers were encountered and the additional effort and cost required to adequately survey for few shore anglers by plane was prohibitive. Aerial boat counts were periodically canceled due to inclement weather. Canceled flights were rescheduled when possible. Flights were rescheduled on the same day type (week day or weekend day) and within the same survey interval.

Angler interviews were conducted to obtain catch rate data and describe angler demographics. Angler interviews were completed on the lake by boat. Creel clerks began interview periods proceeding from south to north beginning in Coolin Bay. We attempted to interview all angling parties on the lake. However, in instances where many angling parties were present a completed circuit of the lake in a timely fashion was difficult. Angling parties were roughly subsampled by geographic area in these conditions. In instances where weather conditions prohibited interviews to safely be conducted by boat, such as high wind and or ice, anglers were intercepted at popular boat ramps including Indian Creek, Kalispell, and Coolin. Most two-week intervals contained six scheduled angler interview events. We scheduled angler interviews on dates and times during which angler counts were conducted. One additional angler interview period was scheduled per week by randomly selecting from remaining available days.

During angler interviews we collected information used to describe catch rates and angler demographics within the angling party. Collected information included number of anglers, angler type (boat or shore), number of rods fished, time spent fishing, targeted species, number of fish kept per species, number of fish released per species and whether a daily trip was completed. The majority of angler interviews were conducted prior to anglers completing their fishing day. If a party’s fishing trip was not completed, that party was provided a postage paid postcard and asked to return the postcard via mail upon trip completion. Postcards allowed anglers to report completed trip information including time fished, catch, and harvest (Appendix A). In addition, a name and phone number was recorded from each party. We used contact information to collect completed trip data in instances when a postcard was not returned. If an angler post card was not received, we attempted to contact that party by phone. We called anglers two to four weeks post-interview, typically making at least two attempts to contact an angler.

Data analysis was completed by Survey Solutions, LLC. Survey Solutions also provided general guidance on survey design.

Effort

Fishing effort for the whole water body was estimated by month. Monthly estimates were derived by first generating daily estimates of effort for each sampled day within a month. Daily fishing effort was computed within the sampled day as the boat count multiplied by the number of possible fishing hours in the sampled day for surveyed days. Average boat counts by day type (weekdays vs. weekends/holidays) within two week sampling intervals were applied to estimates of daily fishing effort. Fishing hours were described as the period between sunset and sunrise and were standardized within a two week sampling interval as the average time within that interval. Daily effort was then summed within the month by day type. Fishing effort was expanded to the whole water body for the entire month by dividing by the sampling probability: $E = e/pt$, where E = total effort (boat hours), e = sampling period effort (daily effort), and pt = temporal sampling probability. Sampling probabilities were estimated by day type as the number days sampled within a month divided by the number of days within the month. Effort estimates by day type were then summed across day type for an estimate of total boat effort hours. Estimates of boat effort hours were expanded to angler hours by multiplying by the average number of anglers per boat over the entire survey, determined from angler interview data. Standard error around boat effort estimates were derived using methods described in Pollock et al. (1994) for stratified random sampling in roving angler surveys. We described the variability around effort estimates by calculating 80% confidence intervals around estimated means using methods for normally distributed data.

In association with our Priest Lake angler survey, we investigated an alternate method of estimating angler effort that had potential for reducing the cost of estimating angler effort and or increasing the frequency of which estimates of angler effort could be generated. Periodic surveys of angler behavior and success are important for understanding the role of anglers in management of recreational fisheries and for evaluating a fisheries success. However, angler surveys typically are labor intensive and expensive to complete, especially on a water body the size of Priest Lake. With an interest in exploring methods of estimating angler effort on Priest Lake with less effort and or expense, we evaluated whether car counts at Priest Lake recreational access sites were adequate predictors of angler effort. We used linear regression to describe the relationship between car counts at the Priest Lake State Park Indian Creek unit and monthly estimates of angler effort generated from aerial counts in this survey. Car counts were collected by remote counting system at the park entrance or by rough visual count during months when the counting system was not operational (personal communication, Lonnie Johnson, Idaho Parks and Recreation).

Catch and Harvest

Catch and harvest rates were reported as the number of fish per angler hour for anglers intending to catch targeted species. A catch rate was derived for an interviewed angler only if that angler harvested or released fish being targeted. A mean daily rate was computed by taking an average of daily catch rate values across the days sampled, for various hierarchies of the survey design. The daily catch rate values were calculated in two different ways. Calculations were dependent on whether interviews were completed (postcard surveys), or partial (Pollock et al. 1994). Catch rates based on completed trip interviews were calculated by the ratio of means estimator. The mean of ratios (mean ratio) estimator was used for partial trip interviews. The total number of fish released, harvested, and caught (harvest + release) were derived by multiplying total fishing effort by the appropriate total rate estimator (harvest, release, or catch) for the various hierarchies of the design. We described the variability around catch and harvest estimates by calculating 80% confidence intervals around estimated means using methods for normally distributed data. We also described the sampling error for estimates of catch rate and harvest as the relative standard error (RSE), defined as (SE/estimate)*100. By standardizing the error term (as a percent), the precision of different variables can be easily compared across temporal and spatial elements of the design.

In this report, our results reference completed trip analysis of catch rates collected from postcards and completed trip interviews. We hypothesized that data from completed angler trips would reduce variability in catch rate estimates associated with the timing of angler interviews relative to when anglers began fishing. We examined differences in catch rates between completed trips and uncompleted trips to describe how our use of completed trip data may have impacted our estimates. We also compared relative standard error estimates of completed and uncompleted trips to determine if completed trip interviews reduced estimate variance. Nonparametric Kruskal-Wallis One Way Analysis of Variance was used to evaluate differences in monthly estimates of catch rate and relative standard error by species for kokanee, Lake Trout, and Smallmouth Bass. Insufficient data were available for comparisons of other species. We used a non-parametric approach as data were typically not normally distributed. In general, this evaluation allowed us to describe the utility of postcards as a survey tool for collecting completed trip data from anglers.

We used estimates of effort and catch rate from this survey and prior surveys to explore trends in the Priest Lake fishery. We gathered historical data from prior angler surveys (Bjornn 1957, Davis et al. 2000, Liter et al. 2009, Irizarry 1975, Mauser and Ellis 1985, Mauser et al. 1987, Reiman et al.1979). In our evaluation, we selected angler surveys that incorporated survey periods most similar to ours and excluded those with significantly shorter survey periods. Our evaluations included species-specific effort and catch rates. Catch rates represented targeted rates for anglers specifically seeking a particular species. It is important to note that early angler surveys did not separate effort or catch rate for Lake Trout and Bull Trout due to overlap in fishing technique. In some cases, early angler surveys reported only harvest or harvest rates. We assumed that the harvest was equal to catch as most fish were likely kept by anglers when caught.

RESULTS

We interviewed 551 angling parties including 1,109 anglers throughout our survey. Resident and non-resident anglers made up 49% and 51% of those interviewed, respectively. Of those parties surveyed 90 had completed their fishing trip for the day at the time of the interview. We provided prepaid postcards to the majority of the 461 parities who were still fishing when interviewed. Anglers returned 242 postcards with completed trip information. Completed trip information was obtained from an additional 122 angling parties through follow up phone calls to postcard recipients.

Effort

Two to six instantaneous counts were completed within each sample strata (108 total counts) and were used to estimate angler effort. Counts of boats varied from zero to 36 boats per count. We estimated anglers fished 46,719 ± 2,990 (80% C.I.) hours between March 1, 2014 and February 28, 2015, representing 10,923 angler trips. On average, we observed 2.1 people fishing and two rods per boat. Mean completed trip length was 4.4 hours and varied by month from 3.8 (August) to 6.4(January and November) hours. Angling effort varied throughout the year, with the highest fishing effort occurring in July (9,940 h) and the lowest effort occurring in November (433 h; Figure 75).

During our survey, anglers primarily targeted Lake Trout and kokanee, representing 67% and 23% of the total effort, respectively (Table 27). Eight percent of angler effort targeted Smallmouth Bass. Approximately one percent of angler effort targeted Westslope Cutthroat Trout. Less than one percent of angler effort targeted other species, including Yellow Perch and Northern Pikeminnow *Ptychocheilus oregonensis*.

We found car counts at the Indian Creek Unit of Priest Lake State Park to be a good predictor of angler effort on Priest Lake during our angler survey. Monthly total counts were available for nine of the twelve months our survey was conducted. Monthly counts explained 85% of the variance in monthly aerial estimates of angler effort (Figure 76).

Catch and Harvest

Kokanee

Anglers harvested an estimated 4,622 ± 1,319 (80% C.I.) kokanee during the survey period (Table 27). An additional, 965 were caught and released. Anglers targeting kokanee caught 0.94 fish per hour. Relative standard error associated with catch and catch rates for kokanee were 21 and 30, respectively. Kokanee harvested by anglers ranged from 245 to 355 mm (n = 15). Anglers targeted kokanee between April and November (Figure 76), although the majority of angling effort occurred in the summer months, June through August. Catch rates were observed to be greatest in October (Figure 77).

Lake Trout

Lake Trout made up the largest portion of targeted angler effort and the highest total catch (Table 27). Anglers harvested 10,787 ± 1,850 (80% C.I.) Lake Trout during the survey period. An additional 5,110 Lake Trout were caught and released. On average, Lake Trout anglers caught 1.1 Lake Trout per hour. Relative standard error associated with catch and catch rates for Lake Trout were 11 and 22, respectively. Lake Trout harvested by anglers ranged from 342 to 691 mm, averaging 493 mm (n = 42). Anglers fished for Lake Trout year round with the majority of angler effort occurring June through August (Figure 76). We observed the highest Lake Trout catch rates in December (Figure 77).

Smallmouth Bass

Anglers targeting Smallmouth Bass experienced the highest catch rates on Priest Lake, averaging 3.27 fish per hour. Anglers caught an estimated 10,139 ± 3,932 (80% C.I.) Smallmouth Bass, releasing most (9,390) of the fish caught (Table 27). Relative standard error associated with catch and catch rates for Smallmouth Bass were 30 and 53, respectively. Anglers targeted

Smallmouth Bass between April and September with the majority (62%) of targeted effort occurring in June and July (Figure 76).

Westslope Cutthroat Trout

We estimated anglers caught 1,567 ± 1,290 (80% C.I.; Table 27) Westslope Cutthroat Trout. Although harvest of Westslope Cutthroat Trout was not legal, limited harvest was observed by creel clerks (*n* = 1), and we estimated anglers kept 71 fish. Average catch rate for Westslope Cutthroat Trout was estimated at 0.64 fish per hour. Few anglers targeted Westslope Cutthroat Trout, and catch rates among anglers were variable. Subsequently, relative standard error associated with catch and catch rates of Westslope Cutthroat Trout were high at 64 and 88, respectively. Anglers targeted Westslope Cutthroat Trout between May and October (Figure 76). However, the majority (66%) of targeted effort occurred in July, as did the majority of the catch (Figure 77).

Other Species

Catch rates and associated harvest of other species including Yellow Perch and Northern Pike minnow were insignificant (Table 27). Targeted angler effort for these species was also insignificant.

Method Comparison

Catch rate estimates for kokanee, Lake Trout, and Smallmouth Bass did not differ significantly between uncompleted and completed trip data (Kruskal-Wallis; P ≥ 0.20; Table 28). However, completed trip data incorporating postcard collections provided more precise estimates of catch rate for kokanee and Lake Trout with lower relative standard errors (Kruskal-Wallis; P ≤ 0.20; Table 29).

DISCUSSION

Our survey demonstrated that angler effort has diversified on Priest Lake, potentially implying that anglers desire greater fishery diversity than has been present in recent decades. Angler effort on Priest Lake in the last several decades has been largely devoted to a single species. Kokanee dominated the fishery in the 1950s, 1960s, and early 1970s, but few to no anglers targeted them by the early 1980s (Bjornn 1957, Irizarry 1975, Mauser and Ellis 1985). Lake Trout were the primary target of anglers on Priest Lake by the early 1980s and we found they were still the most sought after species in our survey (Figure 80). However, we observed angler effort for kokanee and Smallmouth Bass represented a substantial portion of the fishery, accounting for nearly a third of the expended angler effort (Figure 80). Total angler effort expended on Priest Lake during our survey was consistent with the most recent previous angler survey on the lake (Figure 81; Liter et al. 2009), implying shifts in targeted angler effort were not the result of new or additional effort. Shifts in angler effort may be influenced by multiple factors including new fishing opportunities (e.g. kokanee harvest reopened), changes in fish abundance (i.e. more kokanee and Smallmouth Bass), or shifting angler interests. However, these results aligned with public opinion surveys regarding management preferences for Priest Lake fisheries conducted in 2011 (IDFG 2013). In those surveys, public opinion was split between managing primarily for Lake Trout and a diversity of other species. Although our results do not provide specific direction as to how Priest Lake fisheries should be managed, we believe they do support the importance of current efforts by IDFG to engage constituents in a larger discussion about angler preference and the future management of Priest Lake fisheries.

We observed angler effort on Priest Lake was lower than historic levels (Figure 81). Angler effort from the 1950s through the 1970s ranged from 64,000 to 99,000 hours (Bjornn 1957, Irizarry 1975, Reiman et al.1979). Our estimate of angler effort was considerably lower at 46,719 hours. Liter et al. (2003), estimated a similar level of angler effort (41,400 h) potentially indicating that trends in angling effort are stabilizing. A number of factors potentially influencing angler interest in Priest Lake have changed over the monitored history and likely impacted angling effort. Notable changes include major shifts in fish community structure, improved access for lake users (e.g. developed road systems and access points), and increased lake shoreline development. These factors and likely others have the potential to both attract and deter angler interest and as such make it difficult to describe exactly what drives angler effort on Priest Lake.

Targeted Smallmouth Bass effort in our survey was a new development and added diversity in the Priest Lake fishery. Effort targeting Smallmouth Bass had not been observed in previous angler surveys (Liter et al. 2009). The origin of Smallmouth Bass in Priest Lake is uncertain, but anecdotal reports have suggested they were present since the early 2000s (Liter et al. 2009). A survey of Smallmouth Bass abundance and distribution in 2014 suggested distribution was widespread, but density was low (see Priest Lake Investigations chapter in this report). Our results suggest that the population is now established well enough to provide fishing opportunity that is desirable to anglers.

Anglers experienced some of the best catch rates documented on Priest Lake during our survey. Cumulatively, targeted catch rates were good for kokanee, Lake Trout, Smallmouth Bass, and Westslope Cutthroat Trout relative to historical rates (Table 27; Figure 79). Prior surveys documented reasonable catch rates for either kokanee or Lake Trout, but did not concurrently observe good catch rates for both. We observed the highest-ever catch rate for Lake Trout and a moderate catch rate for kokanee, both around one fish per hour. Historically, peak kokanee catch rates were approximately 1.4 fish per hour, suggesting fishing conditions for those seeking kokanee were reasonable. The catch rate of Westslope Cutthroat Trout was comparable to peak rates observed in the 1960s. Targeted catch rate of Smallmouth Bass was also good at over three fish per hour. No previous estimate of Smallmouth Bass catch rate had been estimated on Priest Lake and we assume our observations represented peak conditions relative to this growing population. Catch rates on warmwater fishes, including Smallmouth Bass (estimate lumped multiple species), were comparably less (1.92 fish/h) during the same period on Lake Pend Oreille, another regional water (Bouwens and Jakobowski 2016).

Lake Trout catch rates have increased steadily since the early 1980s, with our survey representing a peak catch rate at approximately one fish per hour. Angling for Lake Trout has dominated the Priest Lake fishery since the early 1980s. Lake Trout have accounted for the majority of the observed fishing effort in previous angler surveys since 1983, despite catch rates being relatively low into the 2000s (Figure 80). It is unclear whether catch rates reflect shifts in abundance, shifts in angling technique, or some combination of the two. Population trend monitoring data were not available to evaluate the role of abundance on catch rate. General observations of angling technique suggested jigging was a popular Lake Trout technique. Anecdotally, we noted anglers using jigging techniques experienced high catch rates, which may have influenced catch rate estimates. Liter et al. (2009) noted anglers jigging for Lake Trout accounted for only 10% of the targeted effort, presumably less than our anecdotal observations.

Kokanee anglers experienced a moderate catch rate of nearly one fish per hour during the survey period, despite estimates of kokanee density in Priest Lake being low (see Priest Lake Investigations chapter in this report). Acoustic estimates of Priest Lake kokanee abundance suggested abundance was considerably lower than other regional kokanee fisheries during the survey period at less than ten adults per hectare (see Priest Lake Investigations chapter in this report). In comparison, Lake Pend Oreille anglers caught more than two kokanee per hour during the same period (Bouwens and Jakobowski 2016). Lake Pend Oreille kokanee densities were greater, estimated at 70 fish per hectare for adults vulnerable to the recreational fishery (Wahl et al. 2016). This comparison suggested fishery success or desirability may not be proportionally linked to kokanee density. As such, our ability to continue to provide a desirable kokanee fishery in Priest Lake may not hinge on dramatically increasing kokanee abundance in the lake. We recommend some consideration be given to evaluating angler satisfaction relative to observed kokanee catch rates and how angler satisfaction relates to future needs to maintain or enhance kokanee abundance.

Targeted angler effort for Westslope Cutthroat Trout continued to represent a minor component of the Priest Lake fishery during our survey, despite moderate catch rates experienced by anglers who targeted them (Table 27). Since the 1950s, Westslope Cutthroat Trout have played an insignificant role in the Priest Lake fishery (Figure 80). However, Westslope Cutthroat Trout have, over this same time period, provided the most stable fishery in the lake. Estimated catch rates for Westslope Cutthroat ranged from approximately 0.2 fish per hour to 0.6 fish per hour between 1956 and 2014, with catch rates in our survey being at the top of this range (Figure 79). Historical angler reports suggested catch rates were higher prior to the 1950s (Bjornn 1957). Although it's reasonable to conceive native Westslope Cutthroat Trout were more abundant prior to the introduction of non-native fishes, such as Lake Trout and kokanee, and that abundance has fluctuated over time, true evaluations of abundance were unavailable to confirm these reports. The Westslope Cutthroat Trout fishery has been regulated under catch-and-release rules since 1988 based on the assumption that stocks were significantly compromised (Mauser et al. 1988). Based on the catch rate history described in this report (Figure 79) and a lack of basic information on Westslope Cutthroat Trout abundance in Priest Lake, it is difficult to confirm stocks were or are impacted by conditions in the lake. As such, we recommend efforts be made to more clearly understand current and future status of Westslope Cutthroat Trout in the lake. In addition, we recommend periodic surveys of lake wide abundance and distribution be completed using a standardized approach as described in 2014 (see Priest Lake Investigations chapter in this report).

Our evaluation of angler postcards and car counts provided support that these methods are plausible alternatives for gathering basic catch rate and angler use data, respectively. Periodic angler surveys are important for understanding the performance of a recreational fishery and the success of management actions. However, the cost and time commitment of completing angler surveys on Priest Lake has limited their frequency. Our use of postcards for gathering completed trip data retained a typical roving interview design and the operational costs were similar. An alternative approach would be to supply anglers with postcards at key access points, potentially reducing the cost associated with boat operations during roving surveys. Similarly, we found a relationship between car counts and angler effort suggesting an alternative approach may prove more efficient for estimation of angler effort from car counts in the future. For example, using car counts to estimate daily boat counts could allow for use of traditional estimators of angler effort and variance in an access type survey design. This type of approach has been used effectively on Dworshak Reservoir, Idaho (Personal Communication, Sean Wilson, Idaho Department of Fish and Game). We recommend car counts be collected at daily intervals to improve the application of car counts in angler effort estimates. Only monthly car counts were available in our survey, which limited our application to monthly summaries of angler effort rather than daily or interval level estimates.

MANAGEMENT RECOMMENDATIONS

1. Continue engaging constituents in a larger discussion about angler preference and the future management of Priest Lake fisheries. Use information to help inform Fisheries Management Plan that will take effect in 2019.

2. Evaluate angler satisfaction relative to observed kokanee catch rates to determine how angler satisfaction relates to future needs to maintain or enhance kokanee abundance.

3. Complete periodic, standardized, lake-wide surveys for Westslope Cutthroat Trout to assess relative abundance, size structure, and distribution.

4. Incorporate angler postcards and car counts at key access points on Priest Lake for more frequent monitoring of angler effort and catch rates.

Table 27. Angler survey results from Priest Lake, Idaho completed from March 1, 2014 to February 28, 2015. Data described by species include estimated angler effort (hours), percent of total effort, estimated catch, harvest, and catch rate (fish/h). Catch rates represent overall rates for anglers targeting individual species.

Target	Angler effort (h)	% of effort	Caught	Harvest	Catch rate
Kokanee	10729	23	5588 (1466)	4622 (1319)	0.94
Lake Trout	31259	67	15900 (2137)	10787 (1850)	1.07
Northern Pikeminnow	106	< 1	1228 (2292)	94 (591)	3.27
Smallmouth Bass	3902	8	10139 (3932)	750 (681)	3.37
Westslope Cutthroat	654	1	1567 (1290)	71 (210)	0.64
Yellow Perch	67	< 1	1857 (2420)	312 (625)	<0.01
Bull Trout	--	--	66 (410)	0	--
Mountain Whitefish	--	--	86 (492)	86 (492)	--
Rainbow Trout	--	--	38 (688)	0	--

Table 28. Monthly targeted catch rates (fish/h) estimated from uncompleted and completed angler trips conducted from March 1, 2014 to February 28, 2015 on Priest Lake, Idaho.

	Kokanee		Lake Trout		Smallmouth Bass	
	Uncompleted	Completed	Uncompleted	Completed	Uncompleted	Completed
March	--	--	0.73	0.64	--	--
April	0.08	0.78	1.43	0.99	0	0.15
May	0.73	0.64	1.61	1.42	1.21	1.25
June	2.19	0.92	0.98	1.9	1.67	2.23
July	0.55	0.8	1.29	0.5	1.06	5.2
August	0.44	0.64	0.27	0.71	2.55	2.99
September	1.07	1.97	0.89	0.56	2.45	1.73
October	1.05	2.38	0.74	0.95	--	--
November	0	0	1.32	1.64	--	--
December	--	--	2.24	3.14	--	--
January	--	--	1.98	1.67	--	--
February	--	--	2.9	2.64	--	--

Table 29. Relative standard errors for monthly targeted catch rates estimated from uncompleted and completed trip angler survey interviews conducted from March 1, 2014 to February 28, 2015 on Priest Lake, Idaho. NA indicates monthly periods where a single data point was available preventing the calculation of relative error.

	Kokanee		Lake Trout		Smallmouth Bass	
	Uncompleted	Completed	Uncompleted	Completed	Uncompleted	Completed
March	--	--	39.5	34.2	--	--
April	96.2	55.6	23.3	21.4	NA	98
May	31.8	29.6	38.6	18.5	NA	NA
June	54	39.4	30.6	18.2	NA	25
July	30.5	22	67.5	22.7	31.5	43.9
August	41.7	29.3	30.9	35.2	43.2	15.6
September	38.3	20.7	30.8	23.3	43.8	36.6
October	62.4	37.6	19.1	21.6	--	--
November	NA	NA	40.7	39.1	--	--
December	--	--	36.4	24.7	--	--
January	--	--	18.5	21	--	--
February	--	--	18.8	20.9	--	--

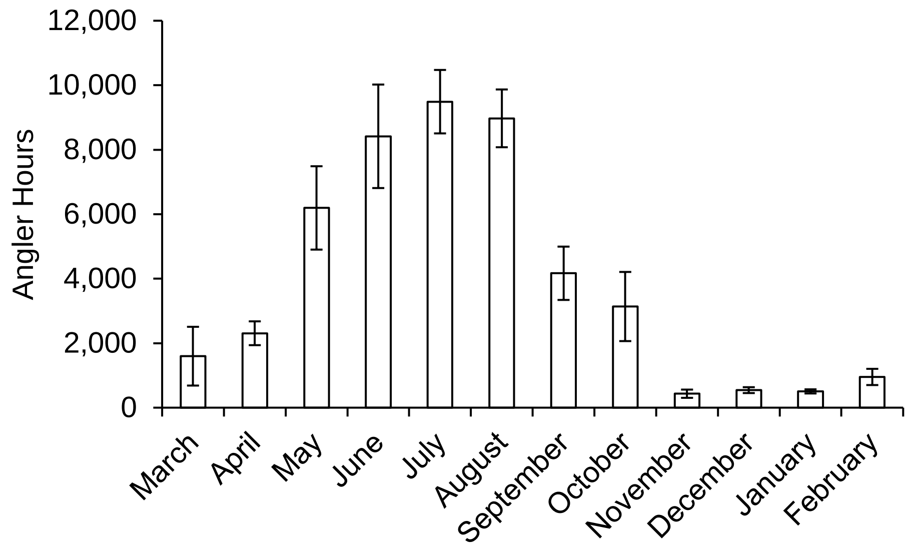

Figure 75. Estimated angling effort (hours, ± 80% C.I.) expended on Priest Lake from March 1, 2014 to February 28, 2015 on Priest Lake, Idaho.

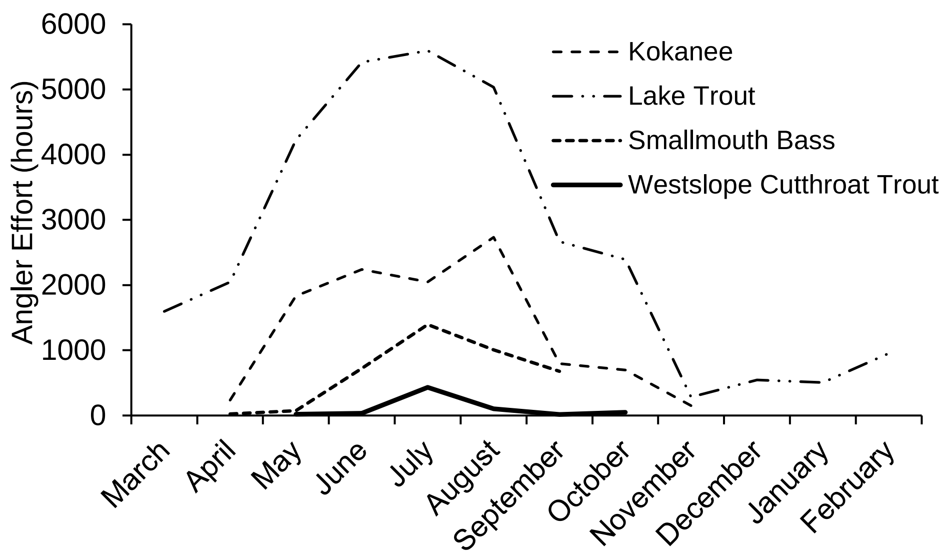

Figure 76. Monthly estimates of targeted angler effort by species for primary species sought by anglers on Priest Lake, Idaho from March 1, 2014 to February 28, 2015.

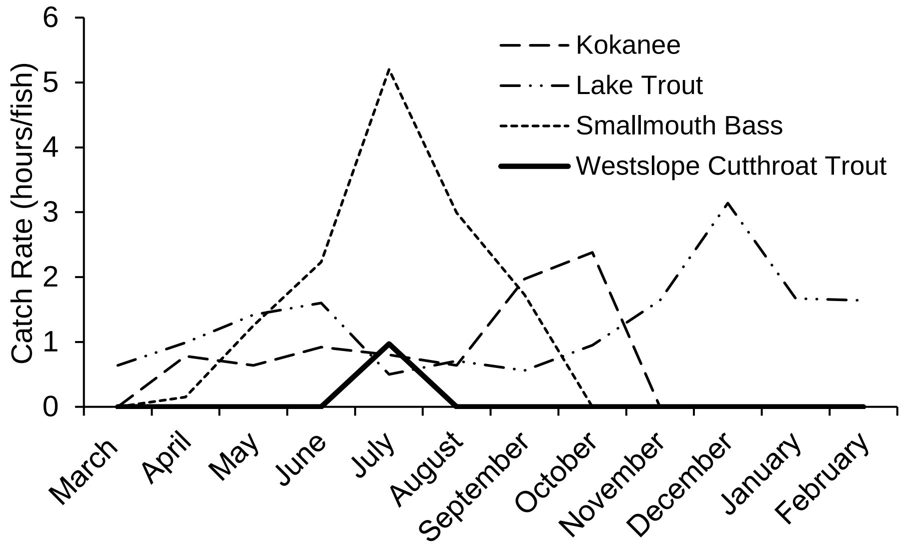

Figure 77. Monthly estimates of targeted catch rate by species for primary species sought by anglers on Priest Lake, Idaho from March 1, 2014 to February 28, 2015.

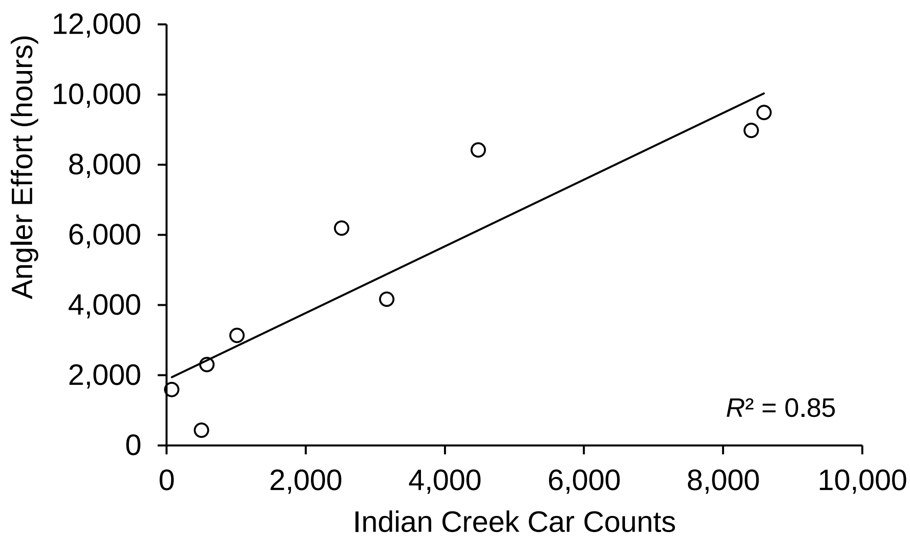

Figure 78. Linear relationship between monthly (March–November) car counts at the Priest Lake State Park Indian Creek Unit and corresponding monthly estimates of angler effort on Priest Lake generated from aerial counts of boat anglers.

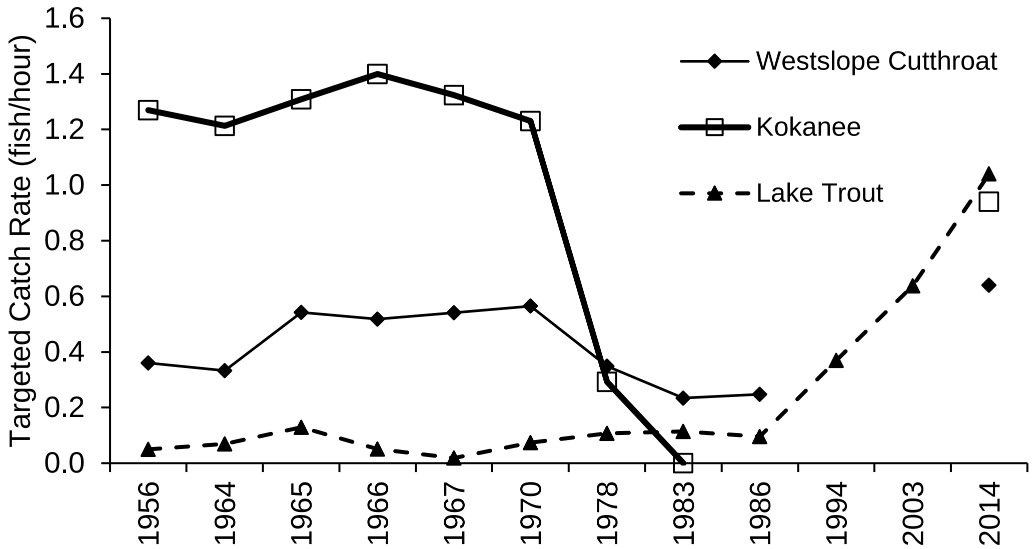

Figure 79. Catch rates estimated during angler surveys on Priest Lake, Idaho from 1956 through 2014 for anglers seeking Westslope Cutthroat Trout, kokanee, and Lake Trout.

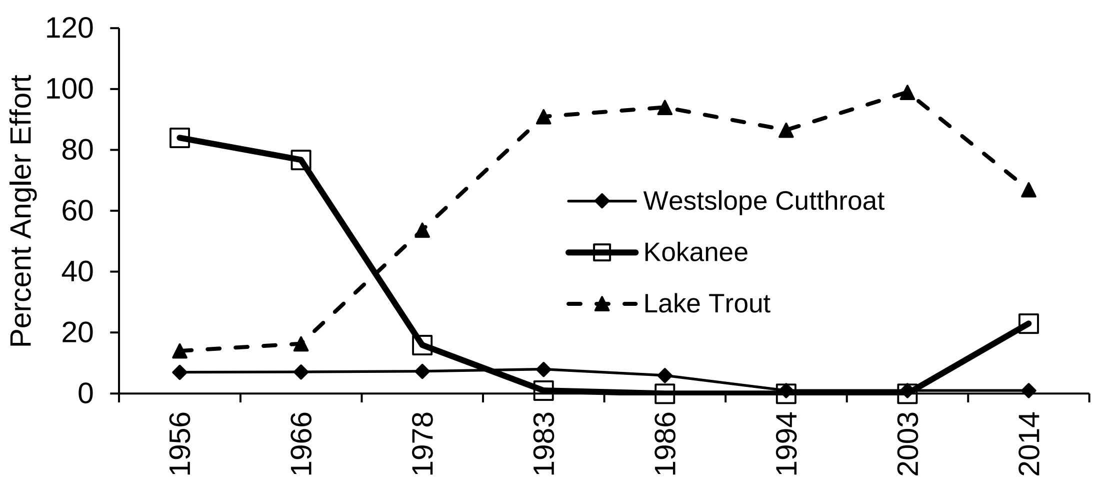

Figure 80. Percent of total angler effort expended by anglers seeking Westslope Cutthroat Trout, kokanee, and Lake Trout from 1956 thru 2014 on Priest Lake, Idaho.

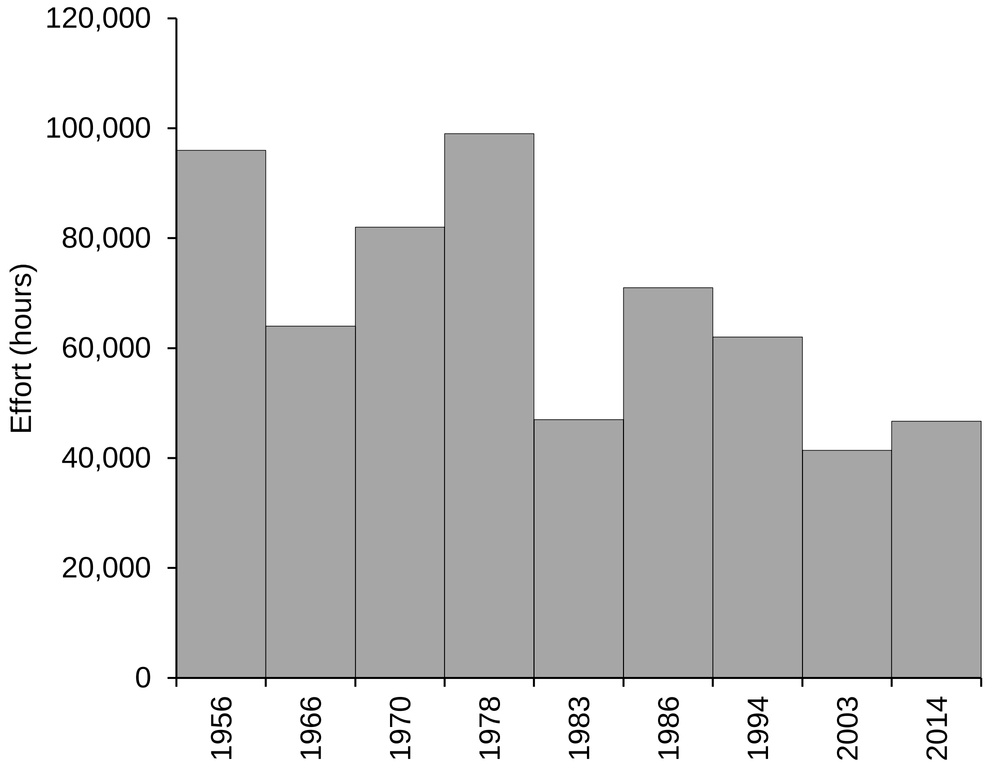

Figure 81. Estimated total angler effort (h) by year from 1956 to 2014 on Priest Lake, Idaho.

PRIEST LAKE FISHERY INVESTIGATIONS

ABSTRACT

In 2014, we investigated several Priest Lake fish populations to evaluate current population characteristics and trends. Investigations included surveys of kokanee, Smallmouth Bass, and Westslope Cutthroat Trout. We conducted a hydroacoustic survey to estimate kokanee abundance. We also monitored kokanee spawner abundance by counting mature adults at five standard shoreline locations. Smallmouth Bass and Westslope Cutthroat Trout surveys were conducted using boat-mounted electrofishing gear and experimental gill nets, respectively. We estimated kokanee densities of 33 fry/ha and 13 age-1 to age-4 fish/ha in our August hydroacoustic survey. In addition, we counted a total of 13,603 kokanee spawners at five standardized shoreline areas. Catch per unit effort of Smallmouth Bass while electrofishing was seven fish/h, and total length varied from 47 to 386 mm TL (*n* = 167).We estimated Smallmouth Bass took 5.4 years to reach quality length and they had low total annual mortality (36%). Proportional stock density of sampled Smallmouth Bass was 37. Fish condition was generally good, with mean relative weights for sub-stock and stock size fish of 98 and 92, respectively. We observed 1.8 Westslope Cutthroat Trout per net night in gill net sets. Westslope Cutthroat Trout ranged from 166 to 445 mm (n = 38). Length-at-age estimates were highly variable, and we estimated juvenile emigration occurred following one to five years of rearing in tributary streams. Total annual mortality of Westslope Cutthroat Trout was 44%. Our results suggested kokanee density was low, but consistent with surveys in 2012 and 2013. Smallmouth Bass catch rates and size structure reflected an established population, but suggested density was low to moderate. Growth of Smallmouth Bass was slow, suggesting the potential for quality size fish was low. Westslope Cutthroat Trout catch rates suggested densities were moderate and sufficient to provide fishing opportunity desirable to anglers.

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INTRODUCTION

Priest Lake is located in Idaho's panhandle about 28 km south of the Canadian border. Surface area of the lake is 9,446 ha. Historically, Priest Lake provided fisheries for Bull Trout *Salvelinus confluentus*, Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, and Mountain Whitefish *Prosopium williamsoni*. Introductions of kokanee *Oncorhynchus nerka*, Lake Trout *Salvelinus namaycush,* Largemouth Bass *Micropterus salmoides,* Smallmouth Bass *Micropterus dolomieu*, and Yellow Perch *Perca flavescens* created additional fishing opportunities that are present today (Liter et al. 2009). The Priest Lake fishery is economically important, with an estimated $5.9 million spent by anglers fishing the lake in 2011(IDFG, unpublished data).

Priest Lake fisheries management has changed significantly since the early 1900's in response to species introductions, social desires, and a variety of other factors. Two of the historically most targeted species by anglers, Bull Trout and Westslope Cutthroat Trout, have been regulated under a "no harvest" scenario since the late-1980's due to real or perceived declines in abundance. Kokanee once supported the primary fishery in the lake and offered significant harvest opportunity. However, kokanee abundance declined through the 1970's and 80's which resulted in a harvest closure. Kokanee densities in the lake remained low, but a harvest fishery was reopened in 2011 and has gained considerable interest among anglers (Fredericks et al. 2013). Historically, Lake Trout occurred at low density, but reached large sizes because of an abundant kokanee prey source. Thus, Lake Trout once supported a popular trophy fishery. However, increased Lake Trout abundance from the 1970's to 90's led to shifting management objectives and the current yield fishery (IDFG 2013). Smallmouth Bass are newly established in Priest Lake and gaining angler interest; thus, they may increasingly influence management decisions in the future.

Management of the Priest Lake fishery in recent decades has been heavily influenced by altered trophic dynamics following the introduction of mysid shrimp *Mysis diluviana* in the 1960's. Fish population responses in Priest Lake closely matched those observed in other western U.S waters after mysid introduction. (Martinez et al. 2009). Mysid shrimp fueled the rapid growth of the Lake Trout population, which was followed by declines in other previously abundant fishes (i.e., kokanee, Bull Trout; IDFG 2013). Additionally, mysid shrimp may compete with kokanee (Chips and Bennet 2000, Spencer et al. 1991) for available zooplankton, although we do not know to what extent this has occurred in Priest Lake. Bull Trout, which were once abundant in the lake, are now nearly extirpated and absent in angler catches. The Bull Trout population in Upper Priest Lake is the exception, having remained relatively stable over the last two decades (see Bull Trout Redd Counts chapter in this report). Westslope Cutthroat Trout were believed to have declined in the Priest Lake system as early as the 1950's (Bjorn 1957). Unfortunately, early information regarding abundance was primarily verbal accounts by anglers and population monitoring has been extremely limited since that time, making comparisons difficult.

Current fishery management objectives for Priest Lake are independent of Upper Priest Lake. However, observations of fish movements through the Thorofare, approximately 3 km of flowing water between Upper Priest Lake and Priest Lake, clearly demonstrate the fish communities within the two lakes are not independent (Venard and Fredericks 2001). Current management priorities include a native species focus in Upper Priest Lake and a mixed species focus, including Lake Trout, kokanee, and Westslope Cutthroat Trout in Priest Lake. The connectivity of these water bodies precludes independent management of their fisheries, thus challenging our ability to meet the contrasting management objectives between lakes. In addition, Priest Lake anglers are currently divided between favoring management for Lake Trout or enhancement of other species (i.e. Westslope Cutthroat Trout, kokanee; IDFG 2013). To address these issues, the Idaho Department of Fish and Game Fisheries Management Plan 2013-2018 indicates a better understanding of the fish communities in this system is necessary to guide future management direction (IDFG 2013).

In 2014, we investigated several Priest Lake fish populations to evaluate current population characteristics and trends. Investigations included surveys of kokanee, Smallmouth Bass, and Westslope Cutthroat Trout. Unlike kokanee, Smallmouth Bass and Westslope Cutthroat Trout have not been previously monitored using standardized survey designs. Thus, the surveys established a baseline for future trend monitoring.

METHODS

Kokanee Monitoring

We conducted a lakewide mobile hydroacoustic survey on Priest Lake to estimate kokanee density and abundance. Surveys were conducted on the nights of July 17 and August 13, 2014. Two surveys were conducted to evaluate how survey timing affected the precision of density estimates. For each survey, we estimated a coefficient of variation for density estimates by transect to measure and compare precision. We also compared

We used a Simrad EK60 split-beam, scientific echosounder with a 120 kHz transducer to estimate kokanee abundance. Ping rate was set at 0.25 to 0.30 seconds per ping. A pole-mounted transducer was located 0.52 m below the surface, off the port side of the boat, and pointed downward. The echosounder was calibrated prior to the survey using a 23 mm copper calibration sphere to set the gain and to adjust for signal attenuation to the sides of the acoustic axis. Prior to each sample, we measured one temperature profile as a calibration of signal speed and to reference the expected depth distribution for kokanee. Water temperatures were measured at one meter intervals from zero to 15 meters using a YSI 85-50 dissolved oxygen and temperature meter (YSI Incorporated). Mean water temperature for water depths between zero and ten meters was used in system calibration. We used Simrad ER60 software (Simrad Yachting) to determine and input the calibration settings.

We used standardized transects to complete the surveys (Maiolie et al. 2013). We followed a uniformly spaced, zigzag pattern of 15 transects stretching from shoreline to shoreline (Figure 82). The zigzag pattern was used to maximize the number of transects that could be completed in one night. The pattern followed the general rule of using a triangular design (zigzags) when the transect length was less than twice the transect spacing (Simmonds and MacLennan 2005). The starting point of the first transect at the northern end of the lake was originally chosen at random. Boat speed was approximately 2.4 m/s.

We determined kokanee abundance using echo integration techniques. Echoview software version 5.4 (Echoview Software Pty Ltd) was used to view and analyze the collected data. A box was drawn around the kokanee layer on each of the echograms and integrated to obtain the nautical area scattering coefficient (NASC) and analyzed to obtain the mean target strength of all returned echoes. This integration accounted for fish that were too close together to detect as a single target (MacLennan and Simmonds 1992). Densities were then calculated by the equation:

$$\text{Density (fish/ha)} = (\text{NASC} / 4\pi 10^{TS/10})\ 0.00292$$

Where NASC is the total backscattering in m^2/nautical mile^2 and TS is the mean target strength in dB for the area sampled.

Kokanee density was estimated directly from the echograms. All fish in the observed pelagic fish layer were identified as kokanee if target strengths of the observed fish were within the expected size range. Size ranges were based on Love's equation, which describes a relationship between target strength and length (Love 1971). A total kokanee density for all fish was calculated by echo integration. A virtual echogram was then built from the corrected target strengths. We next multiplied the total kokanee density estimate for each transect by the percentage of small targets between -60 dB and -45 dB to estimate the density of kokanee fry. The percentage of large targets (-44 dB to -30 dB) were used to estimate density of kokanee age classes one to four.

We calculated kokanee abundance by multiplying estimated densities by the area of available pelagic habitat in Priest Lake. Maiolie et al. (2013) previously estimated 8,190 ha of available pelagic habitat in Priest Lake.

Eighty percent confidence intervals were calculated for each kokanee density estimate. Error bounds calculated for arithmetic mean densities utilized a Student's T distribution. The entire lake was considered to be one section, without spatial stratification.

We monitored kokanee spawner abundance in Priest Lake on November 5, 2014. Spawning kokanee were observed and counted at five standard nearshore areas, located at Copper Bay, Hunt Creek, Cavanaugh Bay, Indian Creek, and Huckleberry Bay. We collected a sample of spawning kokanee adjacent to the mouth of Hunt Creek using monofilament gill nets to obtain size, sex, and age class information. One gillnet was set for 15 minutes. The monofilament gillnet was a 45-m long x 1.8-m tall monofilament, experimental, sinking gill net. The net had six panels with mesh sizes of 3.8, 5.1, 6.4, 7.6, 10.2, and 12.7 cm stretch-measure mesh. We estimated mature kokanee ages by examining freshly removed whole otoliths under a dissecting microscope. Sexes were determined by examining the fish's external characteristics and gonads.

Smallmouth Bass Monitoring

We sampled Smallmouth Bass throughout Priest Lake in an effort to describe relative abundance, distribution, and population characteristics. The survey was conducted on the nights of June 3, 4, and 11, 2014. Smallmouth Bass were collected using a 5.8-meter Smith-Root 5.0 GPP boat-mounted electrofisher and pulsed DC current (60 pulses per second). Electrofishing units of effort were defined as ten minutes of on-time. All sampling was conducted during the dark hours of the night. One netter was used during all sampling. We netted only Smallmouth Bass and Westslope Cutthroat Trout. All fish collected were measured (TL; mm) and weighed (g).

We used a simple random survey design to identify sampling locations. This involved dividing Priest Lake into uniform units by overlaying a UTM grid in Terrain Navigator Pro (MyTopo). All grids units contacting the shoreline were numbered and sampling locations were then chosen at random. We sampled a total of 24 units distributed around the lake (Figure 83).

We described relative abundance using average catch per unit effort (CPUE). We calculated 80% confidence intervals for mean CPUE estimates using methods for normally distributed data. We used our sampling effort and associated estimates of CPUE variance to evaluate sample size goals for future sampling needs. We estimated a required number of electrofishing units to determine mean CPUE with 80% confidence as described in Cochran (1977, also see Bonar et al. 2000). We also estimated required sample size for measuring a 50% change in mean CPUE with 80% confidence as described in Parkinson et al. (1988, also see Bonar et al. 2000).

We collected otoliths from the majority of fish sampled. Otoliths were prepared for age estimation using one or more techniques, including 1) viewing whole otoliths, and 2) breaking centrally, burning or browning the broken edge, and viewing the broken edge with a dissecting microscope at 30 – 40X. Otoliths were coated with mineral oil to improve viewing clarity. Each otolith was viewed by three independent viewers. Differences among viewers were solved by committee. When agreement could not be reached, otoliths were removed from the sample.

We estimated dynamic rates of the Smallmouth Bass population to describe the population and establish a baseline for future comparison. Growth patterns were described using mean length-at-age determined from the sub-sample of fish from which age was estimated. Growth potential was estimated from mean length-at-age using the von Bertalanffy growth function generated in FAST (Fisheries Analysis and Simulation Tools, Version 2.1). Total annual mortality and survival were estimated using a catch curve (Miranda and Bettoli 2007) generated in FAST.

Stock structure and condition indices were also estimated to evaluate the current size structure and condition of the Smallmouth Bass population (Anderson and Neumann 1996). Proportional stock density (PSD) was calculated to characterize size structure of the population. Relative weight was calculated and summarized using the mean within designated size groups. We generated estimates in FAST.

Westslope Cutthroat Trout Monitoring

We used a simple random survey design to describe relative abundance, distribution, and population characteristics of Westslope Cutthroat Trout in Priest Lake. Sampling efforts were conducted on the nights of June 3, 4, and 11, 2014. We identified sampling locations in nearshore areas of Priest Lake using methods previously described for Smallmouth Bass. We sampled 24 sites during the survey (Figure 83).

We sampled Westslope Cutthroat Trout using 45 m long x 1.8 m tall monofilament, experimental, floating gill nets. Gill nets were constructed with six panels and included mesh sizes 3.8, 5.1, 6.4, 7.6, 10.2, and 12.7 cm stretch-measure mesh. Nets were set perpendicular to the shoreline in nearshore areas. All nets were fished overnight with set times ranging from 12 to 19 hours. All fish collected were measured (TL, mm) and weighed (g).

Relative abundance was described as average CPUE (fish/net night). We calculated 80% confidence intervals for mean CPUE estimates. We used our sampling effort and associated estimates of CPUE variance to evaluate sample size goals as previously described for Smallmouth Bass.

We used samples to describe general characteristics of the Priest Lake Westslope Cutthroat Trout population. Age of individual fish was estimated from otoliths. We collected otoliths from all Westslope Cutthroat Trout sampled. Otoliths were prepared for age estimation by using one or more techniques, including 1) viewing whole immediately after removal, 2) viewing whole after drying, and 3) by mounting in epoxy, cross sectioning, mounting cross sections to a slide, sanding, and viewing under a compound microscope at 10x power. Each otolith was viewed by two independent viewers. Differences among viewers were solved by committee. When agreement could not be reached, otoliths were removed from the sample.

We estimated dynamic rates of the Westslope Cutthroat Trout population to describe the population and establish a baseline for future comparison. Growth patterns were described using mean length-at-age determined from the majority of the sampled fish. Total annual mortality and survival were estimated using a catch curve (Miranda and Bettoli 2007) generated in FAST.

Westslope Cutthroat Trout emigration potentially influenced our investigation of age and growth. Adfluvial Westslope Cutthroat Trout spawn and rear in Priest Lake tributaries. Emigration from rearing tributaries may occur following a wide period of rearing (Bjornn 1957). We assumed forage availability and subsequent growth potential might be impacted by where a fish resides and for what period of time. To better understand the influence emigration timing had on age and growth patterns, we estimated the age at emigration for Westslope Cutthroat Trout sampled. Incremental measures of growth were used to estimate the period in which a juvenile fish first emigrated from a stream to Priest Lake. Increments of growth were measured on individual otoliths from the trailing edge of an opaque band to the trailing edge of the next opaque band. We described the year of emigration as the period with the greatest incremental growth.

RESULTS

Kokanee Monitoring

We found kokanee fry density and abundance estimates in July and August were notably different, while estimates of older age classes were similar. Our July 2014 hydroacoustic estimate was 108 kokanee fry/ha (± 63, 80% C.I.) and 10 age-1 to age-4 kokanee/ha (± 2; Table 30). July density estimates expanded yielded an abundance estimate of 886,488 kokanee fry and 78,545 kokanee from ages 1 to 4. Our August 2014 hydroacoustic estimate was 33 kokanee fry/ha (± 10) and 13 age-1 to age-4 kokanee/ha (± 4, Table 31). August expanded densities estimates were 271,705 kokanee fry and 103,706 kokanee from ages 1 to 4. Observed variation in NASC values did not demonstrate strong divergence between July and August surveys with coefficients of variation estimated at 67% and 61% for July and August surveys, respectively.

Target strengths observed during the hydroacoustic surveys showed a bimodal distribution that we used to parse our kokanee fry from older age classes (Figure 84). Based on the bimodal distribution, we split kokanee fry from older age classes at -44.0 dB. Distribution of target strengths included larger individuals than typically observed in most northern Idaho kokanee populations. However, we expected to see larger target strengths given the large size of the fish reported by fishermen and observed during recent spawning surveys.

We counted a total of 13,603 kokanee spawners along five shoreline areas of Priest Lake (Table 32). Counts included 1,960 at Copper Bay, 7,530 at Hunt Creek, 838 at Cavanaugh Bay, 2,750 at Indian Creek, and 525 at Huckleberry Bay. Counts were lower than observed in 2012 and 2013 (Figure 85). We collected 74 kokanee in our gillnet sample of adults near Hunt Creek. Mature adults were both age-3 (28%) and age-4 (72%) and varied in length from 293 to 408 mm. Mean length of mature males was 352 mm at age-3 and 379 mm at age-4. Mature females had a mean length of 348 mm at age-3 and 355 mm at age-4.

Smallmouth Bass Monitoring

We sampled 167 Smallmouth Bass and mean CPUE was 7.3 (± 4.3, 80% C.I.). Fifteen Westslope Cutthroat Trout were sampled incidentally during the survey. Catch was highly variable among sampling locations. Based on the observed variance among samples, we estimated 58 electrofishing units would be required to estimate a mean CPUE for Smallmouth Bass with 80% confidence the estimate was within 20% of the true mean. However, we estimated only 33 sample units were required to detect a 50% change in the population.

Smallmouth Bass total length varied from 47 to 386 mm (*n* = 167; Figure 86). Age was estimated for 166 Smallmouth Bass and all age classes from one to eight were represented. We estimated Priest Lake Smallmouth Bass grew slowly and took 5.4 years to reach quality length (i.e. 280 mm; Figure 87), a size when they become increasingly desirable to anglers. Total annual mortality for Smallmouth Bass ages 2-8 was low at 36% (*n* = 138; Figure 88).

Sub-stock and stock size Smallmouth Bass dominated our collections. We estimated a proportional stock density (PSD) for the population at 37 (±12.5, 95% C.I.). Fish condition was generally good with mean relative weights for sub-stock (*n* = 110) and stock size (*n* = 57) fish of 98 and 92, respectively.

Westslope Cutthroat Trout Monitoring

We sampled 38 Westslope Cutthroat Trout among the 24 gill net sets. However, five net sets pulled loose from their anchored position and did not fish effectively. The five compromised nets accounted for two Westslope Cutthroat Trout. Because these nets did not fish effectively, we only included data from 19 nets in our CPUE estimate. Mean Westslope Cutthroat Trout CPUE was 1.9 fish (± 0.4, 80% C.I.) per net night and catch rates were consistent among nets. Based on the observed variance among nets, we estimated 22 net nights were required to estimate a mean CPUE for Westslope Cutthroat Trout with 80% confidence that the estimate was within 20% of the true mean. Sixteen net nights were required to detect a 50% change in catch rate. We also sampled 12 other species, with catch rates varying from 0.1 to 14.8 fish per net (Table 33).

Westslope Cutthroat Trout total length varied from 166 to 445 mm (*n* = 38; Figure 89). Age estimates varied from ages 2-9 (*n* = 32) and only age-8 fish were absent from that distribution. Length-at-age estimates were highly variable (CV = 4-48%; Figure 90). Variation was greatest for age-2 through age-5, representing differences in length within age groups as much as 200 mm. We estimated juvenile emigration to Priest Lake occurred following one to five years of rearing in tributary streams. The most common period of juvenile emigration (41%) occurred between age-1 and age-2. However, emigration at older ages was substantial with 28% emigrating after four years of tributary rearing.

Total annual mortality for Westslope Cutthroat Trout between age-5 to age-9 was 44% (*n* = 21; Figure 91). Fish younger than age-5 were on the descending limb of the catch curve indicating they were not fully recruited to our gear; thus, these fish were not included in the mortality estimate. Harvest of Westslope Cutthroat Trout was prohibited on Priest Lake during our surveys, and angler surveys have suggested non-compliance is minimal (see Priest Lake Angler Survey chapter in this report). As such, we assumed total annual mortality was largely attributed to natural mortality.

DISCUSSION

Kokanee Monitoring

Kokanee surveys in both July and August reflected a low density population in Priest Lake. In comparison, kokanee density estimates of all age classes from of other regional waters have been much higher (680 kokanee per hectare to 4,300 kokanee per hectare; Maiolie et al. 2013; Wahl et al. 2015) than we observed. Our August density estimate was consistent with similarly-timed surveys in 2012 and 2013, suggesting densities were stable over that time period (Figure 92). In contrast, our July estimate of kokanee fry density was greater than our August estimate. Because differences did exist between survey periods we recommend standardized protocols are important for year-to-year comparison. The cause of differences in fry density estimates was uncertain. However, we noted significant increases in water temperature between surveys (Figure 93) that may have influenced kokanee distribution in the water column.

We did not complete complimentary mid-water trawl surveys in Priest Lake in 2014. The trawl boat was unavailable due to equipment failure. In addition, we failed to observe a “kokanee layer” in either of our hydroacoustic survey efforts. We observed a scattered distribution suggesting trawl catches would have been minimal and highly variable. Trawl efforts on Priest Lake in 2013 aimed at collecting kokanee were of limited use with very few fish collected in two nights of trawling effort (Ryan et al. 2014). Based on the observed annual consistency in hydroacoustic surveys and the ineffectiveness of trawling in 2013, we recommend hydroacoutics as a primary survey tool for the current low density kokanee population in Priest Lake. However, age-specific abundance estimates requires direct sampling of fish and is desired to improve our understanding of year class strength. We recommend trial use of other fish sampling methods, such as suspended gill nets, to improve our ability to monitor Priest Lake kokanee.

Kokanee spawner counts moderated in 2014 relative to previous counts in 2011 through 2013 (Fredericks et al. 2013; Maoilie et al. 2013; Ryan et al. 2014). In 2014, we counted about 50% fewer spawning adults than in 2013. The 2014 count was also lower than counts in 2012 and 2011, but within the potential variability expected from this survey method. Mean length of kokanee spawners remained similar to previous years, suggesting large changes in density were unlikely (Figure 85).

Shoreline spawner counts continued to be used as a crude approximation of the total number of spawners. Counts in 2014 reflected the uncertainty of this method. For example, large numbers of kokanee (1000s) were observed in Hunt Creek, rather than along the shoreline. As such, these fish were not included in our count. Presumably, these fish would have been staged along the shoreline adjacent to the creek mouth prior to the survey. In previous years, large numbers of kokanee have not been observed in Hunt Creek. In addition, surface disturbance from wind on the day of the survey inhibited our ability to count kokanee, particularly as depth increased. The single day counts we conduct annually likely significantly underestimate actual spawner abundance, but continue to provide a broad picture of recruitment potential in the lake. Although shoreline kokanee spawner counts incorporate a large amount of uncertainty, they provide the most reliable metric available for describing abundance trends for mature kokanee at low density in Priest Lake. As such, we recommend continuation of shoreline kokanee spawner counts as a method for monitoring large shifts in adult abundance.

Smallmouth Bass Monitoring

Smallmouth Bass catch rates in our survey suggested the Priest Lake population is now well-established, which is a notable development in recent years. Anecdotal reports from anglers suggested Smallmouth Bass were initially found in Priest Lake in the early 2000's. However, Smallmouth Bass were not documented in the catch during an angler survey of Priest Lake in 2003 (Liter et al. 2009). Although we found Smallmouth Bass widely distributed, our catch rates were low and similar to other regional waters. A comparable survey of the Pend Oreille River in 2010 reported a Smallmouth Bass CPUE of 10 (± 5, 80% C.I.; Maiolie et al. 2011), representing a similarly low density population. Smallmouth Bass were uncommon in the Pend Oreille River in the early 1990s (Bennett and Dupont 1993). In contrast, higher density Smallmouth Bass populations have been described within the region. Hayden Lake surveys in 2015 resulted in a CPUE of approximately15 fish per unit (Carson Watkins, Idaho Dept. of Fish and Game, Personal Communication).

Our observations suggested management of a quality Smallmouth Bass fishery in Priest Lake is unlikely due to limited growth potential. We estimated approximately 10 years was required for Priest Lake Smallmouth Bass to reach 406 mm (quality length; Gablehouse 1984). The current population is dominated by sub-stock sized fish (< 280 mm), and we did not observe any fish over 400 mm. Total annual mortality was low relative to other Smallmouth Bass populations (Beamesderfer and North 1995). As such, it is unlikely that size structure was heavily impacted by fishing mortality. We did not detect fish older than age-8, possibly attributed to the fairly recent growth of the Smallmouth Bass population following their introduction in Priest Lake. Alternatively, length biases associated with sampling Smallmouth Bass in lentic waters are common (Beamesderfer and Rieman 1988) and could have biased our sample. While some sampling bias may have occurred, growth rates were slower than other regional waters, and lend credibility to our results. Maiolie et al. (2011) estimated Pend Oreille River Smallmouth Bass reached 406 mm by age 6, whereas fish in Priest Lake were only about 300 mm at the same age.

The implications of an increasing Smallmouth Bass population in Priest Lake are uncertain. Little historic information has been gathered on littoral fish communities in Priest Lake over the last few decades, making comparisons from our survey impractical. However, periodic assessments of fish communities in the Pend Oreille River suggest increasing Smallmouth Bass populations may impact fish species composition. Maiolie et al. (2011) noted declines in abundance of native cyprinids in the Pend Oreille River in concert with increasing Smallmouth Bass abundance. Similar shifts in fish communities were observed in the Snake River, Idaho (Hebdon et al. 2009). Although investigators were not able to causally link their observations of Smallmouth Bass abundance to changes in the respective fish communities, some correlation seems plausible. To better understand the dynamics of the Priest Lake fish community structure and the potential impacts to existing fish populations and fisheries, we recommend periodic investigation of littoral fish communities.

Westslope Cutthroat Trout Monitoring

The survey design we implemented to sample Westslope Cutthroat Trout initiated a new monitoring effort for this species in Priest Lake and established a baseline for future population trend monitoring. Little in-lake sampling for Westslope Cutthroat Trout in the Priest Lake system had occurred for more than two decades. In addition, prior survey efforts for Westslope Cutthroat Trout often had limitations (e.g., different gear types, limited scope) that made population-level inferences challenging (Mauser 1985, Bjornn 1957, IDFG unpublished data). Although gill nets were previously used on occasion to sample Westslope Cutthroat Trout, limited reporting was available on catch rates or the effectiveness of these sampling efforts (Mauser 1985, Bjornn 1957, IDFG unpublished data). Our use of floating gill nets provided evidence that this gear type was an effective tool for lake-wide Westslope Cutthroat Trout monitoring. We found low variability in catch rates among sets in our survey, allowing for estimation of relative abundance with acceptable error limits and minimal sampling effort. In addition, low variability among net sets provided some reference Westslope Cutthroat Trout were similarly distributed throughout the lake. We recommend floating gill nets for future monitoring surveys of Westslope Cutthroat Trout in Priest Lake and other regional lakes. Conducting similar surveys on other regional large lakes would be beneficial for describing those populations and comparing status between populations.

Our survey provided a reference for the current status of Westslope Cutthroat Trout in Priest Lake. However, interpretation of catch rates from our survey (CPUE = 1.8) was more qualitative than quantitative due to limited availability of comparable data. Rather than making site-specific comparisons of catch rate, we relied on references from other waters where similar gears were used to sample various subspecies of cutthroat trout. For example, floating gill net catch rates of Yellowstone Cutthroat Trout in a 2014 spring survey of Henrys Lake, Idaho were approximately four fish per net (personal communication, Jon Flinders, IDFG). Henrys Lake is a popular fishery known for high densities of Yellowstone Cutthroat Trout and quality fishing (High et al. 2015). Westslope Cutthroat Trout catch rates from similar spring surveys of Flathead Lake, Montana averaged one fish per net (0.2-3.3 fish/net) between 1981 and 2014 (personal communication, Ken Breidinger, Montana Fish Wildlife and Parks). However, Westslope Cutthroat Trout were thought to be a minimal component of the Flathead Lake fishery, so the relationship between gill net catch rates and the quality of the fishery is difficult to assess. Catch rates for Westslope Cutthroat Trout in Upper Priest Lake in 2014 were also similar at three fish per net night (see Upper Priest Lake Lake Trout Control chapter in this report). As noted, within lake comparisons of relative abundance were limited. However, Mauser (1985, IDFG unpublished data) observed catch rates of Priest Lake Westslope Cutthroat Trout in floating gill net sets of approximately two fish per net. Although this account did not provide detailed methods and effort was limited, it provides a rough indication that relative abundance may have been similar in that period. These comparisons suggested our observed catch rates represented more than a fragmented population of Westslope Cutthroat Trout and densities may not be markedly different from prior survey efforts. Although Westslope Cutthroat Trout have consistently represented only a minor component of the Priest Lake fishery since the 1950s (see Priest Lake Angler Survey chapter in this report), our results suggest the population is likely robust enough to provide fishing opportunity that is desirable to anglers.

Difficulties in describing trends in relative abundance highlighted the need for consistent and more frequent sampling of Westslope Cutthroat Trout in Priest Lake. Much of the verbal history of Priest Lake suggests populations were significantly diminished from historical highs and largely absent from Priest Lake (Bjornn 1957, Mauser 1985). In contrast, limited data from angler surveys (see Priest Lake Angler Survey chapter in this report) and results from our survey effort suggest the population may not have changed significantly over the last 60 plus years. However, angler related data may not be suitable for describing population trends as angling regulations have changed over time and targeted angler effort for Westslope Cutthroat Trout has been limited. To increase confidence in our understanding of Priest Lake Westslope Cutthroat Trout, we recommend consistent monitoring of Westslope Cutthroat Trout in Priest Lake be continued using the survey protocol we established.

We observed low precision in our age estimates using otoliths. Possible causes for the variability in our assessments include poor clarity of ageing structures, error by individual observers, and natural variability due to the timing of juvenile outmigration. In our analysis, we attempted to address both structure clarity and observer error. We informally evaluated structure clarity by viewing otoliths in different forms, including freshly removed whole otoliths, dried whole otoliths, and sectioned and mounted otoliths. We found sectioned and mounted otoliths provided the clearest image and used those in our analysis. Although sectioned and mounted otoliths provided the clearest image, otoliths frequently cracked when using a 0.8-mm section. We recommend at least a 0.9-mm section be used. We also reduced the influence of individual observer error by using multiple observers and committee concordance. We suspected a high degree of variability was likely due to the timing of juvenile outmigration. This is supported by the high variability we observed in our estimates of juvenile outmigration age (one to six years). Bjornn (1957) observed similar distribution of juvenile outmigration age in Priest Lake Westslope Cutthroat Trout and noted a wide distribution in growth relative to age.

Juvenile emigration also likely impacted our ability to estimate total annual mortality. Fish younger than age-5 were under-represented in our sample (Figure 91). This represents the same time period during which we found emigration from rearing tributaries may occur. We observed the timing of emigration from rearing streams was not consistent among sampled fish. We believe the impact of this pattern of movement resembled inconsistent recruitment, as all fish within a year class may not have been equally vulnerable to the sampling gear. Accurate assessments of mortality from catch curves rely on assumptions of consistent recruitment among year classes (Miranda and Bettoli 2007). The limitations of our estimates of mortality should be considered prior to making conclusions regarding future trends in mortality rates.

MANAGEMENT RECOMMENDATIONS

1. Utilize both hydroacoustic surveys and spawner counts as tools for monitoring Priest Lake kokanee population trends in low density conditions. Consider new sampling methods for describing population structure (e.g. suspended gill nets).

2. Periodically monitor relative abundance and population characteristics of Smallmouth Bass in Priest Lake to better understand population trends and potential impacts to other fishes.

3. Assess Smallmouth Bass management alternatives (e.g., fishing rules) in Priest Lake that are appropriate given the limited growth potential of the population.

4. Periodically repeat the standardized survey design that we implemented to monitor Westslope Cutthroat Trout population trends in Priest Lake.

Table 30. Hydroacoustic survey results for kokanee in Priest Lake, Idaho on July 13, 2014.

Transect	Single targets	NASC (m^2/nautical mile)	Mean TS (dB)	Total density (fish/ha)	% Fry	Fry density (fish/ha)	% Ages 1-4	Age 1-4 density (fish/ha)
1	74	8.67	-55.16	661	99%	652	1%	9
2	42	14.81	-43.54	78	81%	63	19%	15
3	33	23.88	-41.57	80	82%	65	18%	14
4	35	16.43	-39.50	34	69%	23	31%	11
5	32	22.36	-38.31	35	53%	19	47%	16
6	51	19.24	-42.03	71	86%	62	14%	10
7	20	5.70	-44.12	34	85%	29	15%	5
8	20	9.02	-43.90	51	85%	44	15%	8
9	39	11.49	-42.60	49	87%	42	13%	6
10	60	5.94	-50.34	150	98%	147	2%	2
11	44	16.35	-41.71	56	70%	40	30%	17
12	26	37.43	-35.62	32	52%	16	48%	15
13	12	30.25	-35.70	26	42%	11	58%	15
14	7	1.16	-51.57	0	100%	0	0%	0
15	31	4.41	-56.03	410	100%	410	0%	0
Mean				118		108		10

Table 31. Hydroacoustic survey results for kokanee in Priest Lake, Idaho on August 13, 2014.

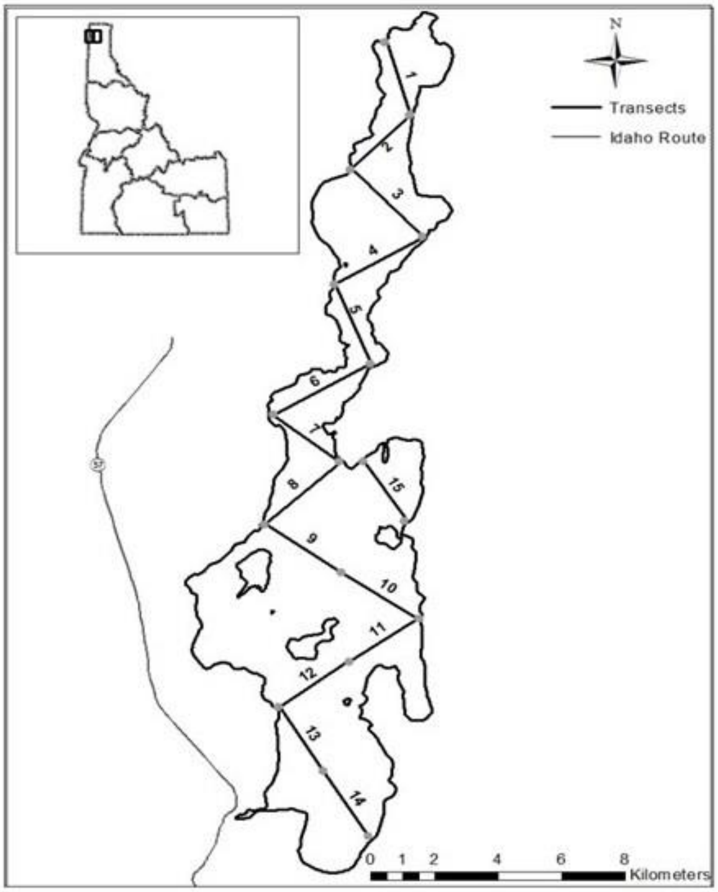
Transect	Single targets	NASC (m^2/nautical mile)	Mean TS (dB)	Total density (fish/ha)	% Fry	Fry density (fish/ha)	% Ages 1-4	Age 1-4 density (fish/ha)
1	17	11.21	-42.15	43	76%	33	24%	10
2	23	9.93	-43.38	50	87%	44	13%	7
3	27	15.94	-40.30	40	67%	26	33%	13
4	23	8.08	-44.70	55	83%	46	17%	10
5	33	30.23	-37.75	42	48%	20	52%	22
6	39	5.34	-46.72	58	85%	49	15%	9
7	38	8.79	-45.14	67	84%	56	16%	11
8	50	17.10	-42.39	69	65%	45	35%	24
9	30	27.89	-37.38	35	70%	25	30%	11
10	49	14.29	-37.98	21	50%	10	50%	10
11	84	20.19	-38.14	31	82%	25	18%	6
12	1	1.38	-56.70	150	74%	111	26%	39
13	0	3.34	-35.68	3	100%	3	0%	0
14	5	11.72	0.00	0	0%	0	0%	0
15	20	15.70	-38.12	24	20%	5	80%	19
Mean				46		33		13

Table 32. Kokanee spawner counts at five standard shoreline locations on Priest Lake, Idaho in 2014.

Location	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014*
Copper Bay	588	549	1237	1584	906	1288	308	223	400	37	750	7995	1070	1960
Cavanaugh Bay	523	921	933	1673	916	972	463	346	550	331	1340	3135	2295	838
Huckleberry Bay	200	49	38	359	120	43	38	0	37	18	90	665	340	525
Indian Creek Bay	222	0	0	441	58	0	40	27	15	49	1050	830	1270	2750
Hunt Creek Mouth	232	306	624	2060	2961	842	1296	884	1635	1410	16103	14570	26770	7530
Total	1765	1825	2832	6117	4961	3145	2145	1480	2637	1845	19333	27195	31745	13603

Table 33. Number (*n*), catch-per-unit-effort (CPUE), minimum total length, maximum total length, and average total length by species for fish sampled from Priest Lake, Idaho in 2014 using standard floating gill nets.

Species	*n*	CPUE	Min TL	Max TL	Avg TL
Brook Trout	14	0.7	188	332	247
Bull Trout	2	0.1	292	299	296
Kokanee	2	0.1	270	282	276
Lake Trout	2	0.1	441	890	666
Largescale Sucker	6	0.3	276	535	421
Longnose Sucker	2	0.1	330	340	335
Mountain Whitefish	1	0.1	352	352	--
Northern Pikeminnow	282	14.8	170	465	318
Peamouth	123	6.5	196	341	281
Smallmouth Bass	17	0.9	203	429	275
Tench	12	0.6	395	510	449
Westslope Cutthroat Trout	38	1.8	166	445	342
Yellow Perch	1	0.1	204	204	--



Transect	Location
1	48° 44.105 N x 116⁰ 51.216 W
	48° 42.752 N x 116⁰ 50.490 W
2	48° 42.752 N x 116⁰ 50.490 W
	48° 41.685 N x 116⁰ 51.965 W
3	48° 41.685 N x 116⁰ 51.965 W
	48° 40.469 N x 116⁰ 50.052 W
4	48° 40.469 N x 116⁰ 50.052 W
	48° 39.509 N x 116⁰ 52.258 W
5	48° 39.509 N x 116⁰ 52.258 W
	48° 38.042 N x 116⁰ 51.267 W
6	48° 38.042 N x 116⁰ 51.267 W
	48° 37.034 N x 116⁰ 53.687 W
7	48° 37.034 N x 116⁰ 53.687 W
	48° 36.185 N x 116⁰ 51.942 W
8	48° 36.185 N x 116⁰ 51.942 W
	48° 34.963 N x 116⁰ 53.804 W
9	48° 34.963 N x 116⁰ 53.804 W
	48° 34.112 N x 116⁰ 51.784 W
10	48° 34.112 N x 116⁰ 51.784 W
	48° 33.288 N x 116⁰ 49.723 W
11	48° 33.288 N x 116⁰ 49.723 W
	48° 32.423 N x 116⁰ 51.475 W
12	48° 32.423 N x 116⁰ 51.475 W
	48° 31.535 N x 116⁰ 53.247 W
13	48° 31.535 N x 116⁰ 53.247 W
	48° 30.357 N x 116⁰ 52.023 W
14	48° 30.357 N x 116⁰ 52.023 W
	48° 29.169 N x 116⁰ 50.815 W
15	48° 36.208 N x 116⁰ 51.323 W
	48° 35.115 N x 116⁰ 50.215 W

Figure 82. Standard transects on Priest Lake, Idaho used in hydroacoustic surveys of kokanee density in both July and August, 2014.

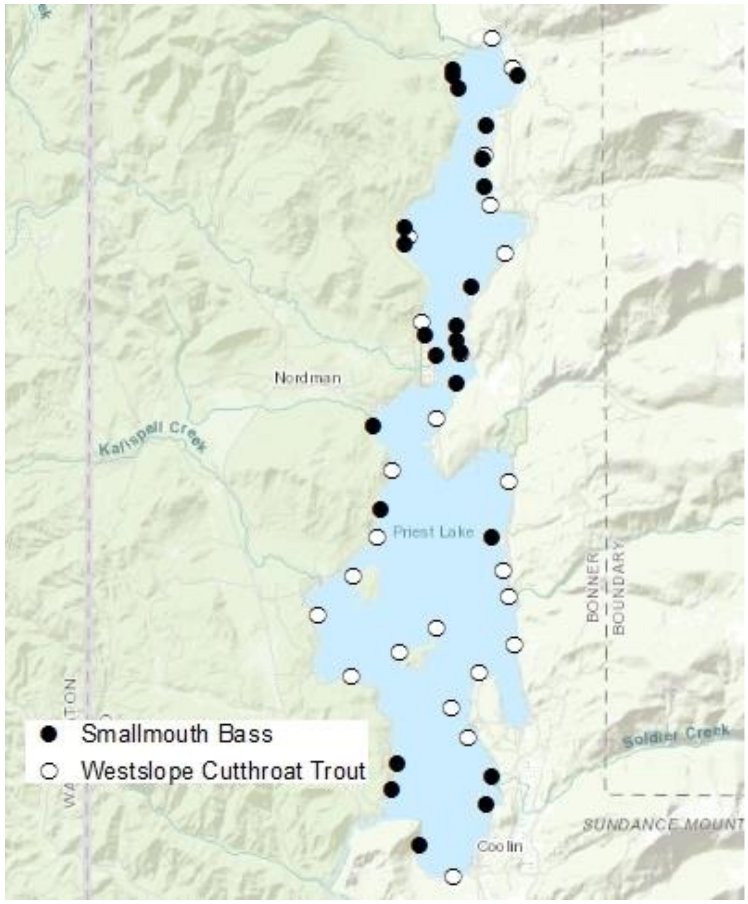


Figure 83. Smallmouth Bass electrofishing sites and Westslope Cutthroat Trout gill net sites sampled in June 2014 on Priest Lake, Idaho.

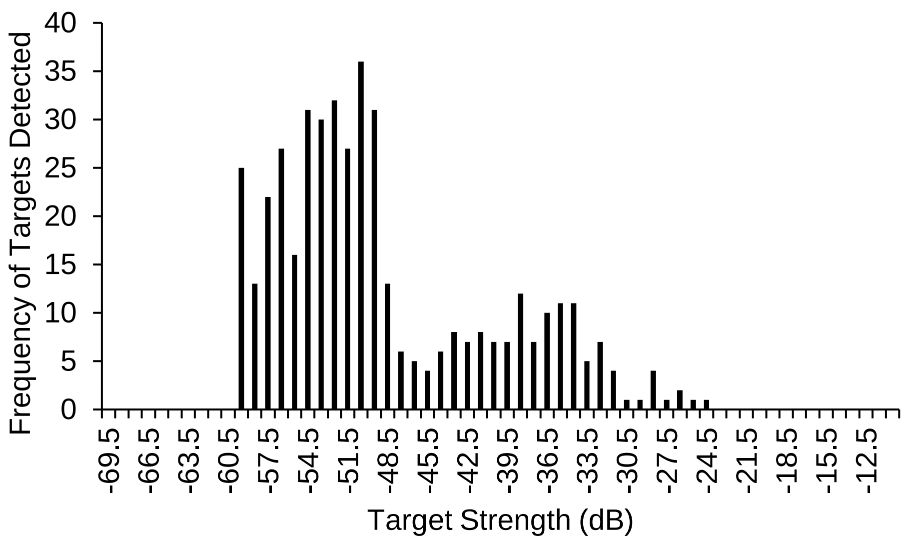


Figure 84. Frequency of target strengths detected in an August 2014 hydroacoutic survey of Priest Lake, Idaho.

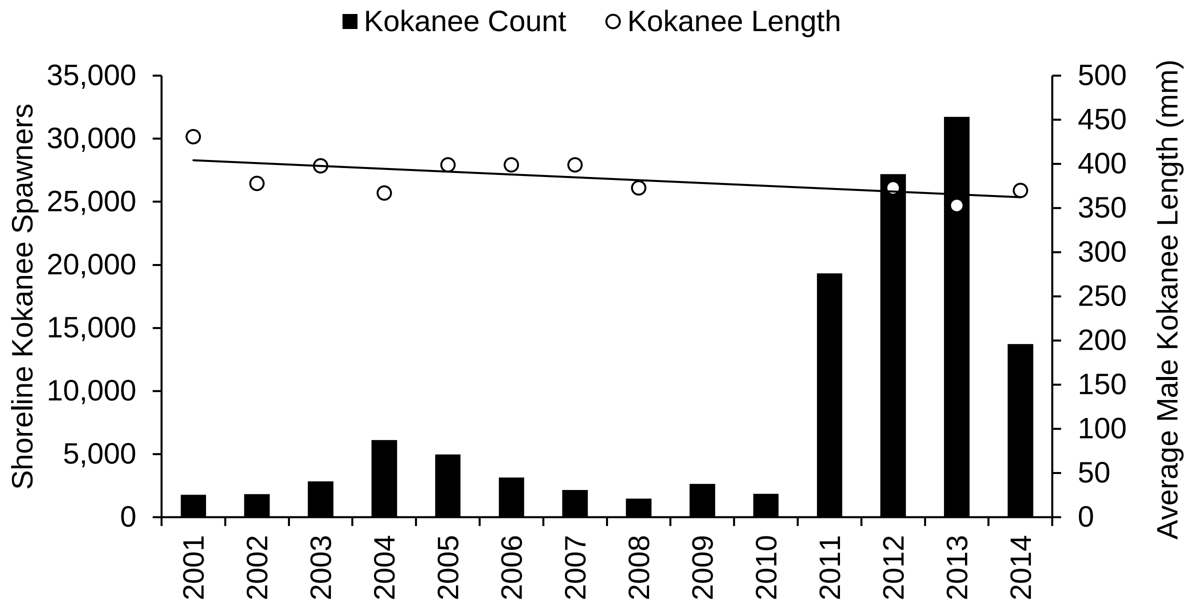


Figure 85. Kokanee adult spawner counts at five standard shoreline locations on Priest Lake, Idaho from 2001 to 2014 and corresponding total length of male kokanee spawners.

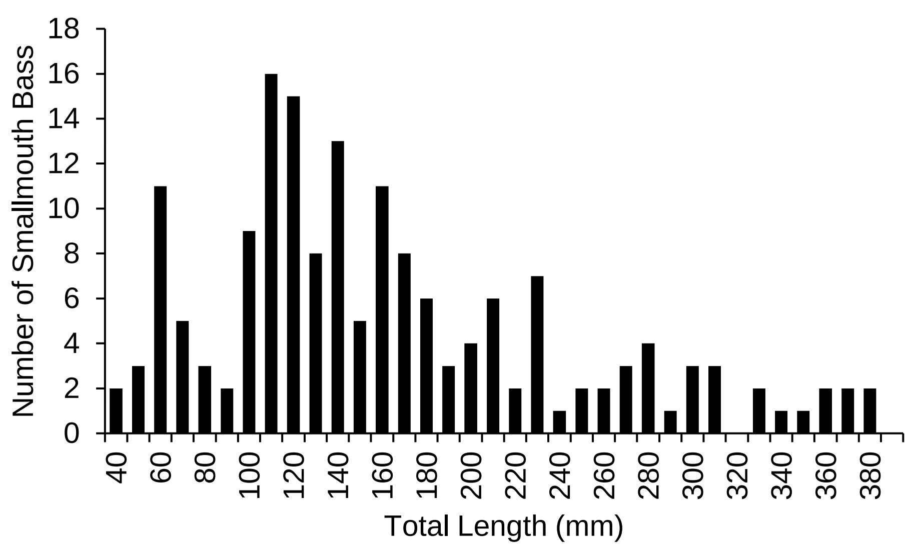


Figure 86. Length frequency of Smallmouth Bass sampled from Priest Lake, Idaho in a June 2014 electrofishing survey.

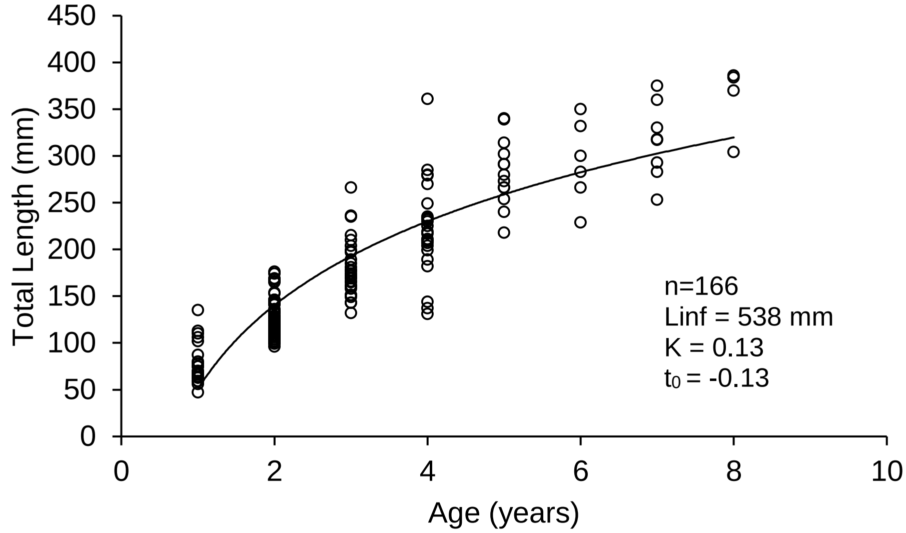


Figure 87. Estimated length-at-age of Smallmouth Bass sampled during a June 2014 electrofishing survey on Priest Lake, Idaho.

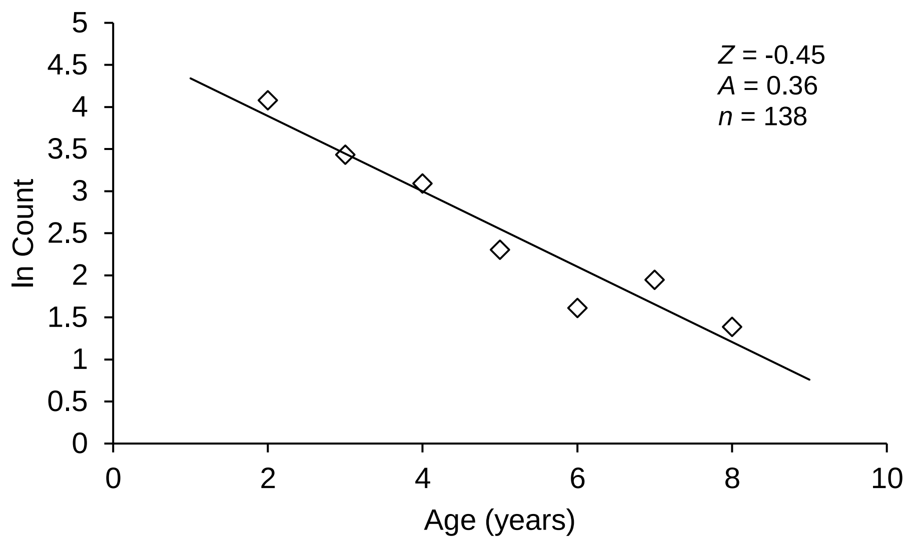


Figure 88. Catch curve regression used to estimate instantaneous mortality (*Z*) and total annual mortality (*A*) for Smallmouth Bass sampled from Priest Lake, Idaho during June 2014.

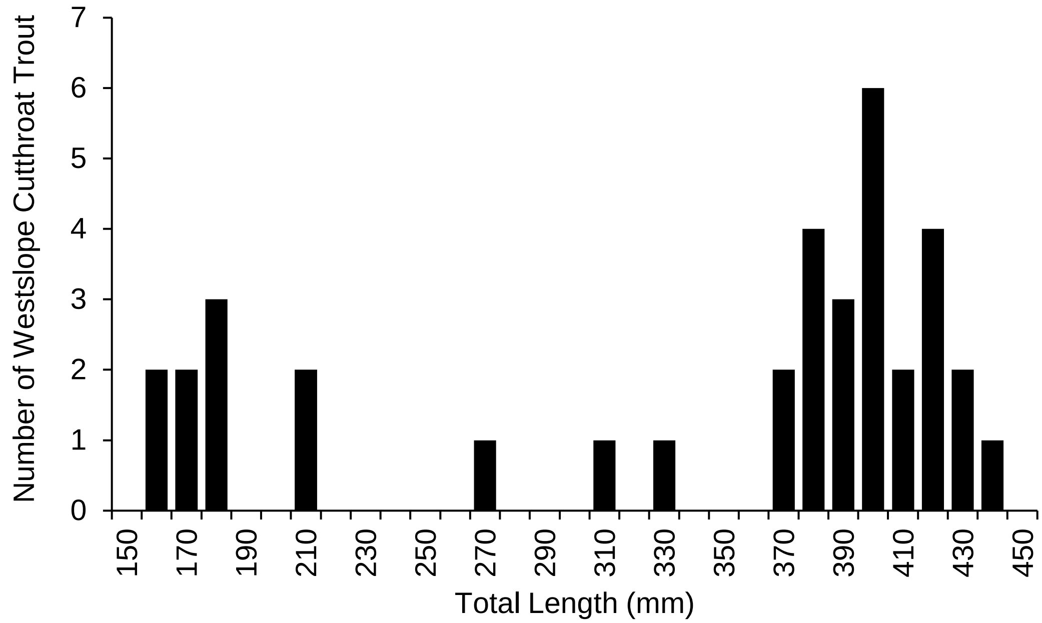


Figure 89. Length-frequency of Westslope Cutthroat Trout sampled from Priest Lake,Idaho during June 2014.

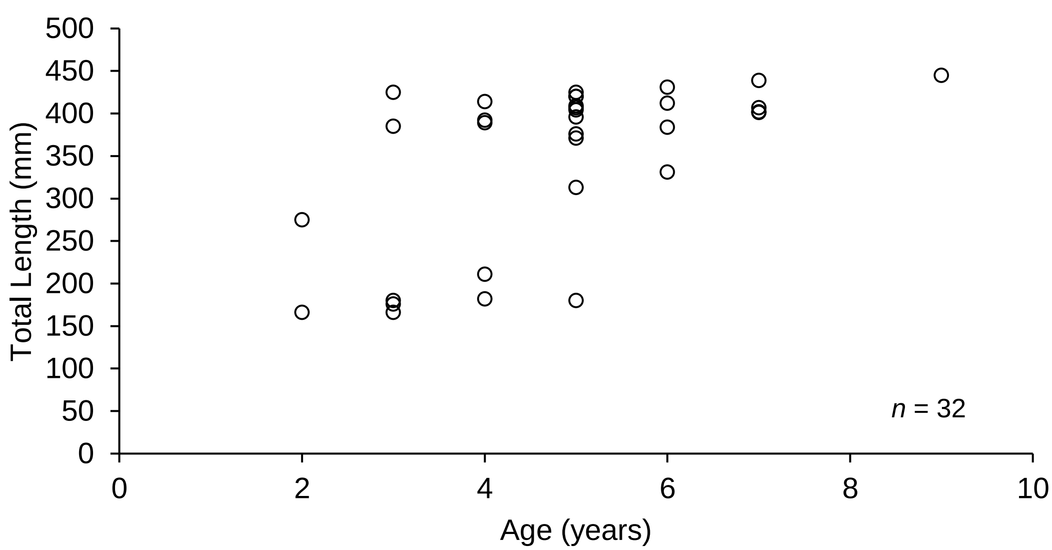


Figure 90. Estimated length-at-age of Westslope Cutthroat Trout sampled from Priest Lake, Idaho during June 2014.

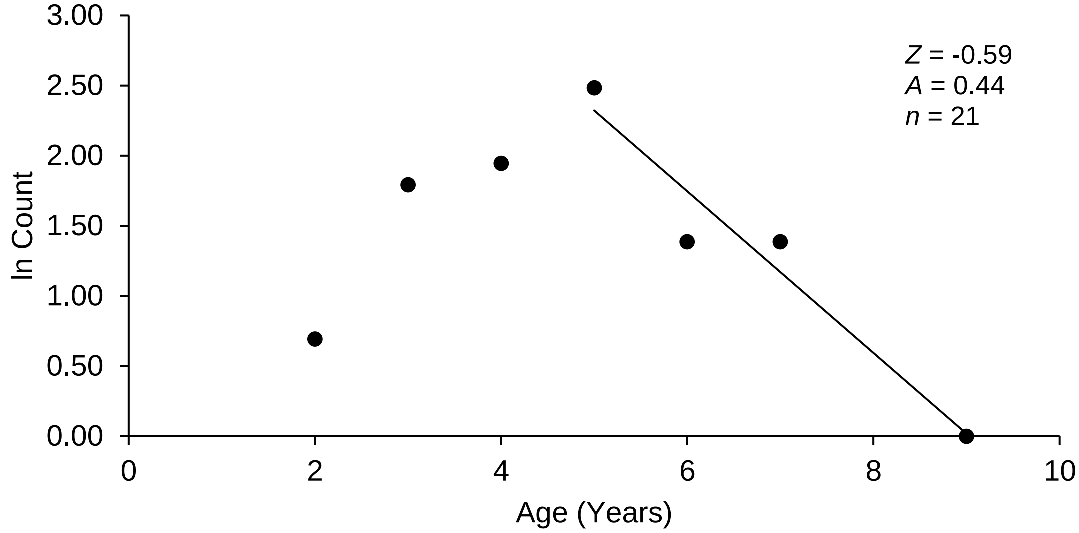


Figure 91. Catch curve regression used to estimate instantaneous mortality (*Z*) and total annual mortality (*A*) for Westslope Cutthroat Trout sampled from Priest Lake, Idaho. Mortality estimates only included ages on the descending limb of the catch curve.

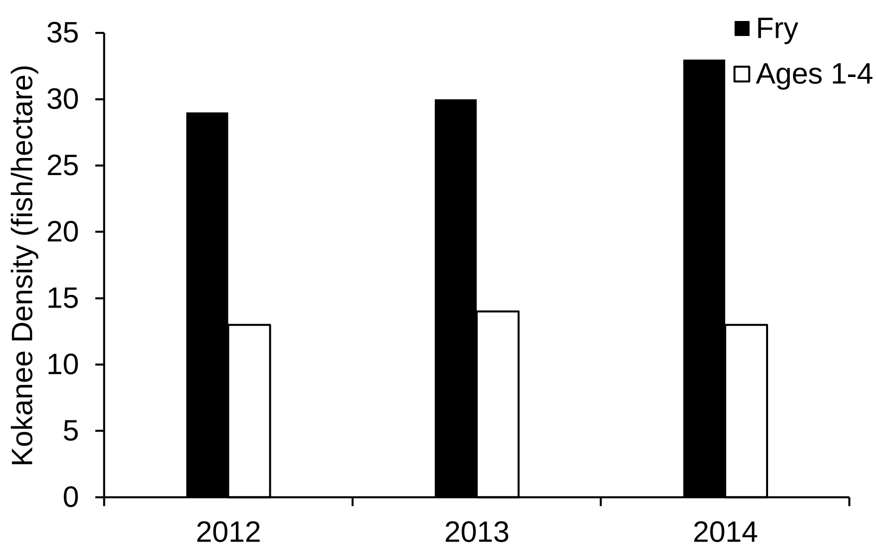


Figure 92. Kokanee density estimates from August hydroacoustic surveys conducted on Priest Lake, Idaho 2012-2014.

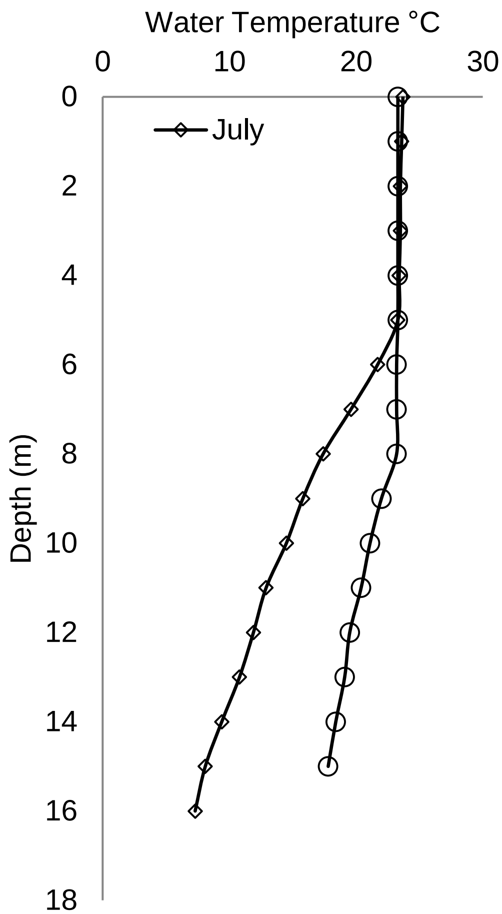


Figure 93. Water temperature profiles measured in July and August 2014 in association with hydroacoustic surveys on Priest Lake, Idaho.

LITERATURE CITED

Allen, M. S. and L. E. Miranda.1995.An evaluation of the value of harvest restrictions in managing crappie fisheries. North American Journal of Fisheries Management 15:766–772.

Allen, M. S. and L. E. Miranda.2001.Quasi-cycles in crappie populations are forced by interactions among populations characteristics and environment. Canadian Journal of Fisheries and Aquatic Sciences 58:594–601.

Allen,M.S., and J. E. Hightower.2010.Fish population dynamics: mortality, growth, and recruitment. Pages 43–79 *in* W. A. Hubert and M. C. Quist, editors. Inland Fisheries Management in North America, 3rd Edition. American Fisheries Society, Bethesda.

Allen, M. S., and W. E. Pine III.2011.Detecting fish population responses to a minimum length limit: effects of variable recruitment and duration of evaluation. North American Journal of Fisheries Management 20:672–682.

Allen, M. S., R. M. Meyers, and C. J. Walters.2008.Temporal trends in largemouth bass mortality, with fisheries implications. North American Journal of Fisheries Management 26:108–118.

Allendorf, F. W., R. F. Leary, N. P. Hitt, K. L. Knudsen, L. L. Lundquist, and P. Spruell.2004.Intercrosses and the U.S. Endangered Species Act: should hybridized populations be included as Westslope Cutthroat Trout? Conservation Biology 18:311–318.

Anderson, R. O.1980.Proportional stock density (PSD) and relative weight (W_r); interpretive indices for fish populations and communities. Pages 27–33 *in* S. Gloss and B. Shupp, editors. Practical fisheries management: more with less in the 1980's. American Fisheries Society, New York Chapter.

Anderson, R. O. and A. S. Weithman.1978.The concept of balance for coolwater fish populations. American Fisheries Society Special Publication 11:371–381.

Anderson, R.O. and R.M. Neumann1996.Passive capture techniques. Pages 95–122 *in* B. R. Murphy and D. W. Willis, editors. Fisheries Techniques. American Fisheries Society, Bethesda.

Bahls, P.1992.The status of fish populations and management of high mountain lakes in the western United States. Northwest Science 66:183–193.

Baker, W.Washington Department of Fish and Wildlife. Personal Communication.6 January, 2015.

Baldwin, C. M., J. G. Mclellan, M. C. Polacek, and K. Underwood.2003.Walleye predation on hatchery releases of kokanees and Rainbow Trout in Lake Roosevelt, Washington. North American Journal of Fisheries Management 23:660–667.

Beamesderfer, R. C. P., and J. A. North.1995.Growth, natural mortality, and predicted response to fishing for largemouth bass and smallmouth bass populations in North America. North American Journal of Fisheries Management 15:688–704.

Beamesderfer, R. C. and B. E. Rieman.1988.Size selectivity and bias in estimates of population statistics of Smallmouth Bass, Walleye, and Northern Squawfish in a Columbia River reservoir. North American Journal of Fisheries Management 8:505–510.

Behnke, R. J.1992.Native trout of western North America. American Fisheries Society, Monograph 6, Bethesda.

Behnke, R. J.2002.Trout and salmon of North America. Free Press, New York.

Bellatty, J. M.,1990.Hayden Lake, Kootenai County, Idaho 1987.Idaho Department of Health and Welfare, Division of Environmental Quality, Water Quality Bureau, Water Quality Status Report 92, 71 pp.

Bennett, D .H. and J. M. DuPont.1993.Fish habitat associations of the Pend Oreille River, Idaho, project F-73-R-15.Idaho Department of Fish and Game, Boise.

Bjornn, T. C.1957.A survey of the fishery resources of Priest and Upper Priest Lakes and their tributaries, project F-24-R.Idaho Department of Fish and Game, Boise.

Blackwell, B. G., M. L. Brown, and D. W. Willis.2000.Relative weight (W_r) status and current use in fisheries assessment and management. Reviews in Fisheries Science 8:1–44.

Bonar, S. A., B. D. Bolding, and M. Divans.2000.Standard Fish Sampling Guidelines for Washington State Ponds and Lake Washington Department of Fish and Wildlife, Olympia.

Bonds, C. C., J. B. Taylor, and J. Leitz.2008.Practices and perceptions of Texas anglers regarding voluntary release of Largemouth Bass and slot length limits. Pages 219–230 in M. S. Allen, S. Sammons, and M. J. Maceina, editors. Balancing Fisheries Management and Water Uses for Impounded River Systems. American Fisheries Society Symposium 62, Bethesda.

Bouwens, K. A. and R. Jakubowski.2016.2014 Lake Pend Oreille creel survey; dissolved gas supersaturation control, mitigation, and monitoring: alternative mitigation and monitoring report. Idaho Department of Fish and Game, Boise.

Bowler, B.1974.Coeur d’Alene River study. Idaho Department of Fish and Game, Federal Aid in Sport Fish Restoration, F-35-R-9, 1974 Job Performance Report Boise.

Bowler, B., B. E. Rieman, and V. L. Ellis.1979. Pend Oreille Lake fisheries investigations. Idaho Department of Fish and Game. Job Performance Report, Project F-73-R-1.Boise.

Boxrucker, J.2002.Rescinding a 254 mm minimum length limit on White Crappie at Ft. Supply Reservoir, Oklahoma: the influence of variable recruitment, compensatory mortality, and anger dissatisfaction. North American Journal of Fisheries Management 22:1340–1348.

Brimmer, B., K. Andrews, T. Curet, and A. Brimmer.2002.Regional fisheries management investigations. Project F-73-R-26, Idaho Department of Fish and Game. Boise.

Brousseau, C. S. and E. R. Armstrong.1987.The role of size limits in Walleye management. Fisheries 12:2–5.

Burnham, K. P., and D. R. Anderson.2002.Model selection and multi-model inference: a practical information theoretic approach, second edition. Springer, New York.

Chen, S. and S. Watanabe.1989.Age dependence and natural mortality coefficients in fish population dynamics. Nippon Suisan Gakkaishi 55:205–208.

Chipps, S. R. and D. H. Bennet.2000.Zooplanktivory and nutrient regeneration by invertebrate (*Mysis relicta*) and vertebrate (*Oncorhynchus nerka*) planktivores: Implications for trophic interactions in oligotrophic lakes. Transactions of the American Fisheries Society 129:569–583.

Cline, T. J., B. C. Weidel, J. F. Kitchell, and J. R. Hodgson.2012.Growth response of largemouth bass (Micropterus salmoides) to catch-and-release angling: a 27-year mark-recapture study. Canadian Journal of Fisheries and Aquatic Sciences 69:224–230.

Cochran, D. W.1992.Sampling Techniques, 3rd Edition. Wiley, New York.

Copeland, T., and K. A. Meyer.2011.Interspecies synchrony in salmonid densities associated with large-scale bioclimatic conditions in central Idaho. Transactions of the American Fisheries Society 140:928–942.

Davis, J. and N. Horner. 1995. Regional fisheries management investigations, 1991 job performance report, F-71-R-16. Idaho Department of Fish and Game, Boise.

Davis, J., L. Nelson, and N. Horner.1995.Regional fisheries management investigations. Idaho Department of Fish and Game, Federal Aid in Sport Fish Restoration, Lowland Lake Investigations, 1994 Job Performance Report, IDFG 00-22, Boise.

Davis, J., L. Nelson, and N. Horner.1996.Regional fisheries management investigations. Idaho Department of Fish and Game, Federal Aid in Sport Fish Restoration, F-71-R-18, 1993 Job Performance Report. Boise.

Davis, J. A, L. Nelson, and N. Horner. 2000.Regional fisheries management investigations, 1994 progress report F-71-R-19. Idaho Department of Fish and Game, Boise.

Dean Jr., W. J.,D. R. Terre, W. B. Dolman, T. W. Schlagenhaft.1991.Largemouth Bass population structure changes and harvest under a slot length limit. Proceedings of the Annual Conference of the Southeast Association of Fish and Wildlife Agencies 45:261–269.

DEQ (Department of Environmental Quality).2001.Subbasin assessment and total maximum daily loads of the North Fork Coeur d'Alene River, Idaho. Department of Environmental Quality. Coeur d'Alene.

Diana, J. S. and R. Salz.1990.Energy storage, growth, and maturation of Yellow Perch from different locations in Saginaw Bay, Michigan. Transactions of the American Fisheries Society 119:976–984.

Diefenbach, M. L., and R. M. Claramunt.2013.Lake Michigan chinook salmon diets: annual evaluation, 2013.Michigan Department of Natural Resources, Federal Aid in Sport Fish Restoration. Charlevoix.

Dillon, J. 1990. Lake and Reservoir Investigations. Forage development and evaluation: Largemouth Bass forage investigations. Idaho Department of Fish and Game, Job Performance Report for 1990, Boise.

Dillon, J. C. and C. B. Alexander.1996.Hatchery trout evaluations, Fishery Research, IDFG 96-28.Idaho Department of Fish and Game, Boise.

Donald, D. B., and Alger.1993.Geographic distribution, species displacement, and niche overlap for lake trout and Bull Trout in mountain lakes. Canadian Journal of Zoology 71:238–247.

Donald, D. B., and D. J. Alger.1989.Evaluation of exploitation as a mean of improving growth in a stunted population of brook trout. North American Journal of Fisheries Management 9:177–183.

Duffy, M. L., J. L. McNulty, and T. E. Mosindy.2000.Identification of sex, maturity, and gonad condition of Walleye (*Stizostedian vitreum*).Ontario Ministry of Natural Resources Northwest Science and Technology, Thunder Bay, Ontario, NWST FG-05.

DuPont J., M. Liter, and N. Horner.2009.Regional fisheries management investigations. Idaho Department of Fish and Game, Federal Aid in Fish Restoration, IDFG 09-109, 2006 Job Performance Report, Boise.

Dupont, J., M. Liter, and N. Horner.2004.Fishery management annual report, 2001 Panhandle Region, IDFG 04-29.Idaho Department of Fish and Game, Boise.

DuPont, J., M. Liter, and N. Horner.2007.Regional fisheries management investigations. Idaho Department of Fish and Game, Federal Aid in Fish Restoration, Upper Priest River Bull Trout Redd Surveys, 2005 Job Performance Report, Boise.

Dupont, J., M. Liter, N. Horner, C. Gidley, B. Stevens, and J. Hughes.2011.Fisheries management annual report for 2007.Idaho Department of Fish and Game, IDFG 10-104, Boise.

Ebbers, M. A.1987.Vital statistics of a Largemouth Bass population in Minnesota from electrofishing and angler-supplied data. North American Journal of Fisheries Management 7:252–259.

Eder, S.1984.Effectiveness of an imposed slot length limit of 12.0–14.9 inches on Largemouth Bass. North American Journal of Fisheries Management 4:469–478.

ESA (U.S. Endangered Species Act of 1973), as amended, Pub. L. No. 93-205, 87 Stat. 884 (Dec. 28, 1973).

Fraser, J. M.1989.Establishment of reproducing populations of brook trout after stocking of interstrain hybrids in Precambrian Shield lakes. North American Journal of Fisheries Management 9:352–363.

Fredenberg, W.2002.Further evidence that lake trout displace Bull Trout in mountain lakes. Intermountain Journal of Sciences 8:143–152.

Fredericks, J. and J. Venard.2001.Bull Trout exotic fish removal, project completion report. Idaho Department of Fish and Game, Boise.

Fredericks, J., and N. Horner.2002.Mountain lakes investigations. Idaho Department of Fish and Game. Job Performance Report. Boise.

Fredericks, J., J. Davis, and N. Horner.1997.Regional fisheries management investigations. Idaho Department of Fish and Game, Federal Aid in Sport Fish Restoration, Panhandle Region Lowland Lakes Investigations, 1996 Job Performance Report, IDFG 99-22, Boise.

Fredericks, J., J. Davis, and N. Horner.1999.Regional fisheries management investigations. Idaho Department of Fish and Game, Federal Aid in Sport Fish Restoration, Panhandle Region Lowland Lakes Investigations, 1998 Job Performance Report, IDFG 01-07, Boise.

Fredericks, J., M. Liter, M. Maiolie, R. Hardy, R. Ryan, D. Ayers, and C. Gidley.2009.Fisheries management annual report for 2008.Idaho Department of Fish and Game, IDFG 09-125, Boise.

Fredericks, J., M. Maiolie, R. Hardy, R. Ryan, M. Liter.2013.Fishery management annual report, 2011 Panhandle Region, IDFG 12-110.Idaho Department of Fish and Game, Boise.

Gabelhouse, D. W.1984.A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 11:273–285.

Gangl, R. S. and D. L. Pereira. 2003. Biological performance indicators for evaluating exploitation of Minnesota's large-lake Walleye fisheries. North American Journal of Fisheries Management. 23:1303–1311.

Garvey, J. E., R. A. Stein, R. A. Russell, and M. T. Bremigan.2003.Exploring mechanisms underlying Largemouth bass recruitment along environmental gradients. Pages 7–23 *in* Philipp, D. P., and M. S. Ridgway, editors. Black Bass: Ecology, Conservation, and Management. American Fisheries Society Symposium 31, Bethesda.

Goodnight, W. H., and G. R. Mauser.1976.Regional fisheries management investigations. Idaho Department of Fish and Game. Federal Aid to Fish and Wildlife Restoration, F-71-R-4, Job Performance Report. Boise.

Goodnight, W. H., and G. R. Mauser.1978.Regional fisheries management investigations. Idaho Department of Fish and Game. Federal Aid to Fish and Wildlife Restoration, F-71-R-4, Job Performance Report. Boise.

Goodnight, W. H., and G. R. Mauser.1980.Regional fisheries management investigations. Idaho Department of Fish and Game. Federal Aid to Fish and Wildlife Restoration, F-71-R-4, Job Performance Report. Boise.

Grunder, S. A., T. J. McArthur, S. Clark, and V. K. Moore.2003.Idaho Department of Fish and Game 2003 Economic Survey Report. Idaho Department of Fish and Game. Boise.

Gulland, J. A.1982.Why do fish numbers vary? Journal of Theoretical Biology 97:69–75.

Gunter, S. J., and R. O. Anderson.1985.Importance of body size to the recruitment process in largemouth bass populations. Transactions of the American Fisheries Society 114:317–327.

Guy, C. S., and D. W. Willis.1995.Population characteristics of black crappies in South Dakota waters: a case for ecosystem-specific management. North American Journal of Fisheries Management 15:754–765.

Hall, D. L.1991.Growth, fecundity, and recruitment responses of stunted brook trout population to density reduction.PhD dissertation.University of British Columbia, Vancouver.

Hall, T. J.1986.Electrofishing catch per hour as an indicator of Largemouth Bass density in Ohio impoundments. North American Journal of Fisheries Management 6:397–400.

Hansen, M. J., M. A. Bozek, J. R. Newby, S. P. Newman, M D. Staggs.1998.Factors affecting recruitment of Walleyes in Escanaba Lake, Wisconsin, 1958–1996.North American Journal of Fisheries Management 18:764–774.

Hansen, M. J., N. J. Horner, M. D. Liter, M. P. Peterson, and M. A. Maiolie.2008.Dynamics of an Increasing Lake Trout Population in Lake Pend Oreille, Idaho, USA. North American Journal Fisheries Management 28:1160–1171.

Hardy, R. S., D. Ayers, and J. Fredericks.2009.Panhandle Region Fishery Management Report. Idaho Department of Fish and Game. Federal Aid in Sport Fish Restoration, Panhandle Region High Mountain Lake Investigations, 2008 Job Performance Report. Boise.

Hardy, R., R. Ryan, M. Liter, M. Maiolie, and J. Fredericks.2010.Fisheries management annual report for 2009.Idaho Department of Fish and Game, IDFG 10-112, Boise.

Hassemer, P. F.1984.Spawning ecology and early life history of kokanee (*Oncorhynchus nerka)* in Couer d'Alene and Pend Oreille lakes, Idaho.Master's thesis.University of Idaho, Moscow.

Hassemer, P. F., and B. E. Rieman.1981.Observations of deepspawning kokanee on artificially created spawning habitat. North American Journal of Fisheries Management 1:173–176.

Havens, A. C., J. B. Murray, K J. Delaney, and K. J. Roth.1987.Fishery Data Series No. 33.Evaluation of enhancement efforts for Rainbow Trout, coho salmon, and chinook salmon in southcentral Alaska, 1986, F-10-2.Alaska Department of Fish and Game. Juneau.

Hebdon, L, Kozfkay, J, and J. Dillon.2009.Fisheries management annual report, Southwest Region–Nampa, 2007.Idaho Department of Fish and Game, Boise.

Henderson, M. A., and A. J. Cass.2011.Effect of smolt size on smolt-to-adult survival for Chilko Lake sockeye salmon (Oncorhynchus nerka).Canadian Journal of Fisheries and Aquatic Sciences 46:988–994.

High, B., D. Garren, G. Schoby, and J. Beulow.2015.Fishery management annual report, upper snake region 2013.Idaho Department of Fish and Game, Boise.

Hill, T. D., and D. W. Willis.1994.Influence of water conductivity on pulsed AC and pulsed DC electrofishing catch rates for Largemouth Bass. North American Journal of Fisheries Management 14:202–207.

Hoenig, J. M.1983.Empirical use of longevity data to estimate mortality rates. Fisheries Bulletin 82:898–903.

Hooe, M. L.1991.Crappie biology and management. North American Journal of Fisheries Management 11:483–484.

Horn, C., J. Hanson, T. Tholl, and K. Duffy.2009.Noxon Reservoir Walleye Life History Study. Avista Corporation, Spokane.

Idaho Department of Fish and Game (IDFG).2013.Fisheries Management Plan 2013–2018.Idaho Department of Fish and Game, Boise.

Idaho Department of Fish and Game (IDFG).2006.Idaho Comprehensive Wildlife Conservation Strategy. As approved by the USDI Fish and Wildlife Service, National Advisory Acceptance Team. February 2006.Boise.

Idaho Department of Fish and Game (IDFG).2013.Management plan for the conservation of Westslope Cutthroat Trout in Idaho. IDFG Fisheries Bureau. Boise.

Irizarry, R. A.1974.Survival, distribution, and use of Mysis relicta by game fish species in north Idaho lakes. Job performance report, VI-a. Idaho Department of Fish and Game, Boise.

Irizarry, R. A.1975.Fisheries investigations in Priest and Upper Priest Lakes, project F-53-R10.Idaho Department of Fish and Game, Boise.

Isely, J. J. and T. B. Grabowski.2007.Age and Growth. Pages 187–228 *in* Analysis and interpretation of freshwater fisheries data, C. S. Guy and M. L. Brown, editors. American Fisheries Society, Bethesda.

Isermann, D. A., and C. T. Knight.2005.A computer program for age-length keys incorporating age assignment to individual fish. North American Journal of Fisheries Management 25:1153–1160.

Isermann, D. A., M. H. Wolter, and J. J. Breeggemann.2010.Estimating Black Crappie age: an assessment of dorsal spines and scales as nonlethal alternatives to otoliths. North American Journal of Fisheries Management 30:1591–1598.

Isermann, D. A., W. L. McKibbin, and D. W. Willis.2002.An analysis of methods for quantifying crappie recruitment variability. North American Journal of Fisheries Management 22:1124–1135.

Jackson, J. R., and R. L. Noble.2000.Relationship between annual variations in reservoir conditions and age-0 largemouth bass year-class strength. Transactions of the American Fisheries Society 129:699–715.

Jensen, A. L.1996.Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Canadian Journal of Fisheries and Aquatic Sciences 53:820–822.

Kennedy, P., and K. A. Meyer.2015.Westslope Cutthroat Trout Trends in Abundance in Idaho. Journal of Fish and Wildlife Management 6:305–317.

Kerr, S. J., A. J. Dextrase, N. P. Lester, C. A. Lewis, H. J. Reitveld.2004.Strategies for managing Walleye in Ontario, Walleye Management Strategies Working Group, Percid Community Synthesis. Ontario Ministry of Natural Resources, Ottawa.

Knapp, R. A., and K. R. Matthews.1998.Eradication of nonnative fish by gill netting from a small mountain lake in California. Restoration Ecology 6:207–213.

Knapp, R. A., K. R. Matthews, and O. Sarnelle.2001b.Resistance and resilience of alpine lake fauna to fish introductions. Ecological Monographs 71:401–421.

Knapp, R. A., P. S. Corn, D. E. Schindler.2001a.The introduction of nonnative fish into wilderness lakes: good, intentions, conflicting mandates, and unintended consequences. Ecosystems 4:275–278.

Knight, A.2009.Mountain lake investigations. Idaho Department of Fish and Game. Job Performance Report. Boise.

Koch, J. D., and M. C. Quist.2007.A technique for preparing fin rays and spines for age and growth analysis. North American Journal of Fisheries Management 27:781–784.

Koch, J. D., W. J. Schreck, and M. C. Quist.2008.Standardized removal and sectioning locations for shovelnose sturgeon fin rays. Fisheries Management and Ecology 15:139–145.

Koenig, M.2012.Use of tiger muskellunge to remove brook trout from high mountain lakes. Idaho Department of Fish and Game. Federal Aid to Sport Fish Restoration, F-73-R-34, Annual Performance Report. Boise.

Koenig, M. K., A. E. Butts, J. R. Kozfkay, J. Yates, and D. Downing.2015.Fisheries Management Annual Report Southwest Region 2013.Idaho Department of Fish and Game, Report 15-102.Boise.

Lamansky, J. A. Jr.2011.Project 5 lake and reservoir research, F-73-R-31.Idaho Department of Fish and Game, Boise.

Landres, P., S. Meyer, and S. Matthews.2001.The Wilderness Act and fish stocking: an overview of legislation, judicial interpretation, and agency implementation. Ecosystems 4:287–295.

Lewynsky, V. A.1986.Evaluation of special angling regulations in the Coeur d'Alene River trout fishery.M.S. Thesis. University of Idaho, Moscow.

Liter, M., J. Dupont, and N. Horner.2007.Fishery management annual report, 2002 Panhandle Region, IDFG 07-26.Idaho Department of Fish and Game, Boise.

Liter, M., J. Dupont, and N. Horner.2009.Fishery management annual report, 2003 Panhandle Region, IDFG 06-21.Idaho Department of Fish and Game, Boise.

Liter, M., J. Dupont, and N. Horner.2008.Fisheries management annual report. Idaho Department of Fish and Game, Progress Report for 2005, Boise.

Love, R. H.1971.Dorsal-aspect target strength of an individual fish. Journal of the Acoustic Society of America 49:816–823.

Maceina, M. J.1997.Simple application of using residuals from catch-curve regressions to assess year-class strength in fish. Fisheries Research 32:115–121.

MacLennan, D. N. and E. J. Simmonds.1992.Fishery Acoustics. Chapman and Hall, New York.

Maiolie, M, and J. Fredericks.2014.Regional fisheries management investigations. Idaho Department of Fish and Game, Federal Aid in Sport Fish Restoration, Coeur d'Alene Lake Fishery Investigations, 2013 Job Performance Report, IDFG 14-102, Boise.

Maiolie, M. A., W. Harryman, and W. J. Ament.2004.Lake Pend Oreille Fishery Recovery Project. Idaho Department of Fish and Game. Annual Performance Report, Report Number 04-40. Boise.

Maiolie, M. K. Carter-Lynn, J. Fredericks, R. Ryan, and M. Liter.2013.Fisheries management annual report for 2012.Idaho Department of Fish and Game, IDFG 13-116, Boise.

Maiolie, M., J. Davis, and N. Horner.1991.Fishery management annual report, 1989 Panhandle Region, F-71-R-14.Idaho Department of Fish and Game, Boise.

Maiolie, M., R. Hardy, M. Liter, R. Ryan, K. Carter-Lynn, and J. Fredericks.2011.Fishery management annual report, panhandle region 2010, IDFG 11-117.Idaho Department of Fish and Game, Boise.

Marnell, L. F.1988.Status of the Westslope Cutthroat Trout in Glacier National Park, Montana. Pages 61–70 in R. E. Gresswell, editor.Status and management of interior stocks of Cutthroat Trout. American Fisheries Society. Symposium 4, Bethesda.

Martinez, P. J.,P. E. Bigelow, M. A. Deleray, W. A. Fredenberg, B. S. Hansen, N. J. Horner, S. K. Lehr, R. W. Schneidervin, S. A. Tolentino, and A. E. Viola.2009.Western lake trout woes. Fisheries 34:9.

Matthews, K. R., and R. A. Knapp.1999.A study of high mountain lake fish stocking effects in the U.S. Sierra Nevada Wilderness. Intermountain Journal of Wilderness 5:24–26.

Mauser, G.1978.Hayden Lake management plan. Idaho Fish and Game, Boise.

Mauser, G. R, and N. Horner.1982.Regional fishery management investigations. Idaho Department of Fish and Game. Federal Aid to Fish and Wildlife Restoration, F-71-R-6, Job Performance Report. Boise.

Mauser, G. R.1986.Enhancement of trout in large, north Idaho lakes. Federal Aid in Fish Restoration; Job Performance Report, Project F-73-R-6.Idaho Department of Fish and Game, Boise.

Mauser, G. R., R. W. Vogelsang, and C. L. Smith.1988.Lake and Reservoir Investigations: Enhancement of trout in large north Idaho lakes. Federal Aid in Fish Restoration; Job Performance Report, Project F-73-R-9.Idaho Department of Fish and Game, Boise.

Mauser, G. R. and V. Ellis.1985.Enhancement of trout in large north Idaho lakes, project F-73-R-6.Idaho Department of Fish and Game, Boise.

Mauser, G. R. Vogelslang, R. W., and C. Smith.1987.Enhancement of trout in large north Idaho lakes, project F-73-R-6.Idaho Department of Fish and Game, Boise.

McCauley, R. W., and D. M. Kilgour.2011.Effects of air temperature on growth of largemouth bass in North America. Transactions of the American Fisheries Society 119:276–281.

McDonald, D. G.1969.Post-tagging mortality of pike, perch, Walleye and Rainbow Trout following dart tag application. Alberta Department of Lands and Forests, Fish and Wildlife Division Management Report 7, Edmonton.

Meyer, K. A., S. F. Elle, J. A. Lamansky Jr., E. R. J. M. Mamer, and A. E. Butts.2012.A reward-recovery study to estimate tagged-fish reporting rates by Idaho anglers. North American Journal of Fisheries Management 32:696–703.

Montana Fish, Wildlife, and Parks (MFWP).2012.Fort Peck Reservoir Fisheries Management Plan 2012–2022.Montana Fish, Wildlife, and Parks, Fisheries Management. Glasgow.

Mink, L. L., R. E. Williams, and A. T. Wallace.1971.Effects of industrial and domestic effluents on the Coeur d'Alene River basin. Idaho Bureau of Miners and Geology. Pamphlet 140.Moscow.

Miranda, L. E.2009.Standardized electrofishing power for boat electrofishing. Pages 223–230 *in* S. A. Bonar, W. A. Hubert, and D. W. Willis, editors. Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bethesda.

Miranda, L. E. and P. W. Bettoli.2007.Mortality.Pages 229–277 *in* C. S. Guy and M. L. Brown, editors. Analysis and interpretation of freshwater fisheries data. American Fisheries Society, Bethesda.

Morgan, G. E.2002.Manual of instructions–fall Walleye index netting (FWIN).Percid community synthesis, diagnostics, and sampling standards working group. Cooperative Freshwater Ecology Unit, Sudbury.

Muhlfeld, C. C., D. H. Bennett, R. K. Steinhorst, B. Marotz, and M. Boyer.2008.Using bioenergetics modeling to estimate consumption of native juvenile salmonids by nonnative Northern Pike in the upper Flathead River system, Montana. North American Journal of Fisheries Management 28:636–648.

Muth, K. M. and D. R. Wolfret.1986.Changes in growth and maturity of Walleyes associated with stock rehabilitation in western Lake Erie, 1964–1983.North American Journal of Fisheries Management 6:168–175.

Nelson, L., J. Davis, N. Horner.1996.Regional fisheries management investigations, 1993 job performance report, F-71-R-18.Idaho Department of Fish and Game, Boise.

Neumann, R. M. and M. S. Allen.2007.Size Structure. Pages 37–421 *in* C. S. Guy and M. L. Brown, editors. Analysis and interpretation of freshwater fisheries data. American Fisheries Society, Bethesda.

Neumann, R. M., C. S. Guy, and D. W. Willis.2012.Length, weight, and associated structural indices. Pages 637–670 in A. V. Zale, D. L. Parrish, and T. M. Sutton, editors. Fisheries Techniques, 3rd Edition. American Fisheries Society, Bethesda.

Neumann, R. M. and D. W. Willis.1995.Seasonal variation in gill-net sample indexes for Northern Pike collected from a glacial prairie lake. North American Journal of Fisheries Management 15:838–844.

Niimi, A. J., and F. W. H. Beamish.1974.Bioenergetics and growth of largemouth bass (*Micropterus salmoides*) in relation to body weight and temperature. Canadian Journal of Zoology 52:447–456.

Olson, M. H.1996.Ontogenetic niche shifts in largemouth bass: variability and consequences for first-year growth. Ecology 77:179–190.

Panhandle Bull Trout Technical Advisory Team (PBAT).1998.Lake Pend Oreille key watershed Bull Trout problem assessment. Idaho Department of Environmental Quality, Boise.

Parker, B. R., D. W. Schindler, D. B. Donald, and R. S. Anderson.2000.The effects of stocking and removal of a nonnative salmonid on the plankton of an alpine lake. Ecosystems 4:334–345.

Parkinson, E. A., J. Berkowitz, C. J. Bull.1988.Sample Size Requirements for Detecting Changes in Some Fisheries Statistics from Small Trout Lakes. North American Journal of Fisheries Management 8:181–190.

Pauly, D.1980.On the interrelationship between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. Journal du Conseil International pour l'Exploration de la Mer 39:175–192.

Peterson, D. P., B. E. Reiman, M. K. Young, and J. A. Bramer.2010.Modeling predicts that redd trampling by cattle may contribute to population declines of native trout. Ecological Applications 20:954–966.

Peterson, I. and J. S. Wroblewski.1984.Mortality rate of fishes in the pelagic ecosystem. Canadian Journal of Fisheries and Aquatic Sciences 41:1117–1120.

Pierce, R. B. and C. M. Tomcko.1995.Exploitation of Northern Pike in seven small north-central Minnesota lakes. North American Journal of Fisheries Management 15:601–609.

Pilliod, D. S., and C. R. Peterson.2000.Evaluating effects of fish stocking on amphibian populations in wilderness lakes. USDA Forest Service Proceedings 5:328–335.

Pister. E. P.2001.Wilderness fish stocking: history and perspective .Ecosystems 4:279–286.

Pollock, K. H., C. M. Jones, and T. L. Brown.1994.Angler survey methods and their applications in fisheries management. American Fisheries Society Special Publication 25, Bethesda.

Pratt, K. L.1984.Pend Oreille trout and char life history study. Idaho Department of Fish and Game, Boise.

Quigley, T. M., R. W. Haynes, and R. T. Graham.1996.Integrated scientific assessment for ecosystem management in the interior Columbia basin and portions of the Klamath and Great Basins. General Technical Report PNW-GTR-382.United States Forest Service, Pacific Northwest Research Station. Portland.

Quinn, T. J., II, and R. B. Deriso.1999.Quantitative fish dynamics. Oxford University Press, New York.

Quist, M. C.2007.An evaluation of techniques used to index recruitment variations and year-class strength. North American Journal of Fisheries Management 27:30–42.

Quist, M. C., and J. R. Speigel.2010.Population demographics of catostomids in large river ecosystems: effects of discharge and temperature on recruitment dynamics and growth. River Research and Applications 28:1567–1586.

Quist, M. C., M. A. Pegg, and D. R. Devries.2012.Age and Growth. Pages 677–731 *in* A. V. Zale, D. L. Parrish, and T. M. Sutton, editors .Fisheries techniques, 3rd edition. American Fisheries Society, Bethesda.

R Development Core Team.2012.R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available: www.R-project.org. (February 2012).

Rankel, G. L.1971.An appraisal of the cutthroat trout fishery of the St. Joe River. Master's Thesis, University of Idaho, Moscow.

Rich, B. A.1992.Population dynamics, food habits, movement, and habitat use of Northern Pike in the Coeur d'Alene River system. M.S. Thesis. University of Idaho, Moscow.

Ricker, W. E.1975.Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Rieman, B. E.1987.Fishing and population dynamics of largemouth bass (Micropterus salmoides) in select northern Idaho lakes. Ph.D. dissertation. University of Idaho, Moscow.

Rieman, B. E. 1992.Status and analysis of salmonids fisheries: kokanee salmon population dynamics and kokanee salmon monitoring guidelines. Idaho Department of Fish and Game. Job Performance Report, Project F-73-R-14.Boise.

Rieman, B. E., and D. Meyers.1991.Kokanee population dynamics. Idaho Department of Fish and Game. Job Completion Report. Project F-73-R-14.Boise.

Rieman, B. E., and L. LaBolle.1980. Lake and reservoir investigations. Idaho Department of Fish and Game, Federal Aid in Sport Fish Restoration, Coeur d'Alene Lake Fisheries Investigations, 1996 Job Performance Report, IDFG F-73-R-2, Boise.

Rieman, B. E., B. Bowler, J. R. Lukens, and P. F. Hassemer.1979.Lake and reservoir investigations, project F-73-R-1.Idaho Department of Fish and Game, Boise.

Ryan, R. G., E. Gutknecht, and D. J. Megargle.2009.Regional fisheries management investigations, Magic Valley Region 2007, IDFG 08-114.Boise.

Ryan, R., M. Maiolie, K. Yallaly, C. Lawson, and J. Fredericks.2014.Fisheries management annual report for 2013.Idaho Department of Fish and Game, IDFG 14-102, Boise.

Sanderson, B. L., T. R. Hrabik, J. J. Magnuson, and D. M. Post.1999.Cyclic dynamics of a Yellow Perch (Perca flavescens) population in an oligotrophic lake: evidence for the role of intraspecific interactions. Canadian journal of fisheries and aquatic science 56:1534–1542.

Sass, G. G., S. W. Hewett, T D. Beard Jr, A. H. Fayram, and J. F. Kitchell.2004.The role of density dependence in growth patterns of ceded territory Walleye populations of northern Wisconsin: effects of changing management regimes. North American Journal of Fisheries Management 24:1262–1278.

Schneider, J. C., R. P. O'Neal, and R. D. Clark, Jr.2007.Ecology, management, and status of Walleye, Sauger, and Yellow Perch in Michigan. Michigan Department of Natural Resources, Fisheries Special Report 41, Ann Arbor.

Schneidervin, R. W., and W. A. Hubert.1986.A rapid technique for otolith removal from salmonids and catostomids. North American Journal of Fisheries Management 6:287.

Schnell, K.2014.Predicted effects of angler harvest on largemouth bass populations in northern Wisconsin lakes. M.S. Thesis. University of Wisconsin—Steven's Point, Steven's Point.

Schoby, G. P., T. P. Bassista, and M. A. Maiolie.2007.Effects of higher winter water levels on the Pend Oreille River fish community, Lake Pend Oreille Fishery Recovery Project. Report 07-15.Idaho Department of Fish and Game, Boise.

Schriever, E. B., and P. D. Murphy.2012.Utilization of tiger muskellunge for controlling self-sustaining populations of introduced brook trout in mountain lakes. Regional Fisheries Management Investigations. Idaho Department of Fish and Game. Boise.

Seber, G. A., and C. J. Wild.2006.Nonlinear regression. John Wiley and Sons, Inc., New York.800 pp.

Shepard, B. B., B. E. May, and W. Urie.2005.Status and conservation of westslope cutthroat trout within the western United States. North American Journal of Fisheries Management 25:1426–1440.

Simmonds, J., and D. MacLennan.2005.Fisheries acoustics theory and practice. Blackwell Science, Oxford.

Slipke, J. W., and M. J. Maceina.2000.Fishery analyses and simulation tools (FAST 1.0).Auburn University, Auburn.

Soltero, R. A., and J. A. Hall.1984.Water Quality assessment of Spirit Lake, Idaho. M.S. Thesis. Eastern Washington University, Cheney.

Spencer, C. N., R. B. McClelland, J. A. Stanford.1991.Shrimp stocking, salmon collapse, and eagle displacement. Biological Sciences Faculty Publications, 292.

Spiegel, J. R., M. C. Quist, and J. E. Morris.2010.Precision of scales and pectoral fin rays for estimating age of highfin carpsucker, quillback carpsucker, and river carpsucker. Journal of Freshwater Ecology 25:271–278.

Stevens, B. S., and J. M. DuPont.2011.Summer use of side-channel thermal refugia by salmonids in the North Fork Coeur d'Alene River, Idaho. North American Journal of Fisheries Management 31:683–692.

Strong, C. C., and C. S. Webb.1970.White pine: king of many waters. Mountain Press Publishing Co. Missoula.

Swain, D. P., A. F. Sinclair, and J. M. Hanson.2007.Evolutionary response to size-selective mortality in an exploited fish population. Proceedings of the Royal Society B 274:1015–1022.

Swingle, H. S.1950.Relationships and dynamics of balanced and unbalanced fish populations. Agricultural Experiment Station of the Alabama Polytechnic Institute Bulletin No. 274. 74 pps.

Teuscher, D.1999.A simple method for monitoring zooplankton forage and evaluating flatwater stocking programs. Idaho Department of Fish and Game, Fisheries Research Brief, No. 99-02, Jerome.

Thurow, R. F.1994.Underwater methods for study of salmonids in the Intermountain West. General Technical Reports INT-GTR-307.Ogden, Utah: U.S. Department of Agriculture, Forest Service, Intermountain Research Station.28p.

U.S. Office of the Federal Register.1998.Endangered and threatened wildlife and plants; 90- day finding and commencement of status review for a petition to list the Westslope Cutthroat Trout as threatened. Federal Register 63:111 (10 June 1998):31691–31693.

U.S. Office of the Federal Register.2003.Endangered and threatened wildlife and plants: reconsidered finding for an amended petition to list the Westslope Cutthroat Trout as threatened throughout its range. Federal Register 68:152 (7 August 2003):46989–47009.

Von Bertalanffy, L.1938.A quantitative theory of organic growth (Inquiries on growth laws. II).Human Biology 10:181–213.

Wahl, N., M. P. Corsi, J. R. Buchanan, W. J. Ament, and W. H. Harryman.2016.Lake Pend Oreille research, 2014 annual progress report IDFG # 16-14.Idaho Department of Fish and Game, Boise.

Wahl, N. C., A. M. Dux, M. R. Campbell, W. J. Ament, and W. Harryman.2015.Lake Pend Oreille fishery recovery project, 2012 performance report 15-04.Idaho Department of Fish and Game, Boise.

Wallace, R. L., and D. W. Zaroban.2013.Native fishes of Idaho. American Fisheries Society, Bethesda.

Walrath, J. D.2013.Population dynamics and trophic ecology of Northern Pike and Smallmouth Bass in Coeur d'Alene Lake: implications for the conservation and management of Westslope Cutthroat Trout. M.S. thesis. University of Idaho, Moscow.

Washington Department of Fish and Wildlife (WDFW).2005.Results of the 2005 WDFW fall Walleye index netting (FWIN) surveys, Sprague Lake, Scooteny Reservoir, Moses Lake, Potholes Reservoir, Banks Lake, and Lake Roosevelt. http://wdfw.wa.gov.

Webb, M. A. and R. A. Ott Jr.1991.Effects of length and bag limits on population structure and harvest of White Crappie in three Texas reservoirs. North American Journal of Fisheries Management 11:614–622.

Weisberg, S., G. Spangler, and L. S. Richmond.2010.Mixed effects models for fish growth. Canadian Journal of Fisheries and Aquatic Sciences 67:269–277.

Wersal, R. M., J. D. Madsen, T. E. Woolf, and N. Eckberg.2010.Assessment of herbicide efficacy on Eurasian Watermilfoil and impacts to the native submersed plant community in Hayden Lake, Idaho, USA. Journal of Aquatic Plant Management 48:5–11.

Winter, J. D.1977.Summer home range movements and habitat use by four largemouth bass in Mary Lake, Minnesota. Transactions of the American Fisheries Society 106:323–330.

APPENDICES

Appendix A. Postcard distributed to anglers encountered fishing on Priest Lake, Idaho during angler survey interviews from March 1, 2014 thru February 28, 2015.

What time did you start and stop fishing today?

1st time Start time:___________ am or pm Stop time: _______________ am or pm

2nd time Start time: ___________ am to pm Stop time: ______________ am or pm

Did you keep any fish today? □No □Yes

If yes, how many? ______Kokanee _______Lake Trout ______ Cutthroat Trout

______Smallmouth Bass _______ Other _____________(list what type)

Did you release any fish today? □No □Yes

If yes, how many? ______Kokanee _______Lake Trout ______ Cutthroat Trout

______Smallmouth Bass _______ Other _____________(list what type)

Comments: ____

____

____

Office Use ONLY: M Tu Wed Th Fr Sa Su Date__________ Code: ________

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